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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 86, No. 6, pp. 367–373 NOVEMBER, 1959

THE EFECT OF SALINITY AND TEMPERATURE ON MARINE AND OTHER FUNGI FROM VARIOUS CLIMATES[1]

DON RITCHIE

Some fungi from tropical marine habitats grow faster in high than in low concentrations of salt as long as a relatively high temperature is maintained. When incubated near the lower end of their temperature range, they grow fastest in a less saline medium. Such a growth pattern having been found first in a marine species of *Phoma* (Ritchie 1957), it may be conveniently called the *Phoma* pattern, and will be thus referred to in the present paper.

Because the organisms which showed the *Phoma* pattern were all collected from the same habitat, i.e., the oceans surrounding the Isthmus of Panama, the results of the experiments raised a question as to the behavior of other fungi from varied habitats. Does an increased salt requirement accompany an increased temperature in fungi generally, or in marine species only, or just in special types which were by chance investigated first?

To answer this, the experiments which led to the initial discovery of the *Phoma* pattern were repeated on organisms collected from marine and terrestrial habitats, both tropical and temperate.

Materials and methods. The procedure was basically similar to that which gave the results mentioned above. Natural sea water with a salinity of 34 parts per thousand was used to make a series of media, either by dilution with distilled water or by partial evaporation and reconstitution to desired strengths. The final concentrations were at 10, 25, 34, 55, 80, and 102 parts per thousand. The media, solidified with 1.5% agar, contained 0.5% glucose and 0.1% yeast extract.

At the higher concentrations, autoclaving causes some precipitation of insoluble salts, and the concentrations at the beginning of a run were not as high, in terms of osmotically active materials, as the stated per cent of total solids might indicate. In time, however, after some water was lost by evaporation, the concentrations became somewhat higher than they were originally. If the culture dishes were sealed in closed containers to prevent evaporation, the resultant condensation caused the colonies to grow too irregular to measure.

[1] This work was supported by funds from the American Academy of Arts and Sciences, and from the National Science Foundation.

[THE BULLETIN for September–October 1959 (86: 283–366) was issued October 15, 1959.]

Five organisms were used. The tropical species was a strain of *Aspergillus flavus* Link from a non-aquatic source in Panama. Two fungi from Delaware Bay, near Cape Henlopen, were taken from water having a temperature, in April, 1957, of about 13° C. They were a *Curvularia*, morphologically similar to *C. interseminata* Berkeley and Ravenel, and an unidentified species of *Chaetophoma*. An isolate of *Helicoma* from the Biological Station at Nanaimo, British Columbia, was taken in October, 1957, from water at 12.5° C. Although the Pacific waters at that place are generally somewhat cooler than those of Delaware Bay, the actual temperatures at collecting times were, because of the seasons, nearly the same. The temperate, terrestrial form was *Mucor spinescens* Lendner, from Pennsylvania soil.

Cultures were incubated at 6°, 16°, 25°, 30°, and 37° C. A few special runs were made at 7°, 20°, 33°, and 42° C.

Growth was recorded in terms of colony diameters, measured from the hyphal tips on one advancing edge to the opposite edge. Although abundant sporulation usually accompanied fast growth, the production of reproductive structures was never used in these experiments as a criterion of growth.

All experiments were made in triplicate. The work on any one species was done at one time, each species being taken as a separate run.

Results and conclusions. The responses of the organisms to the various environments, as shown in figures 1–5, are such as to preclude generalization, except one mentioning the individuality of species. The curves do, however, permit speculation concerning the possibilities of distribution in nature of the strains tested.

The tropical, terrestrial *A. flavus* has a high optimum temperature, the 36-degree cultures being the fastest growing of the series (fig. 1). At that temperature, it showed the greatest salt requirement, growing somewhat better in media containing 25–35 parts per thousand than it did in one containing only 10. Even on a medium containing 100 parts per thousand, this plant grew satisfactorily as long as the temperature was relatively high. Its temperature tolerance dropped off abruptly, however, and it failed to develop, regardless of salinity, in a 42-degree incubator. The salinity optimum was not effectively reduced by a lower incubation temperature.

This *Aspergillus*, although it was isolated from a terrestrial source, has the ability to grow very well at temperatures and salinities which might be met in marine or estuarine habitats. One could expect that, given adequate nutrition, it could thrive in the sea. *Aspergilli* do, in fact, occur commonly in salt-water collections.

The two salt-water forms from Delaware Bay differed from each other. *Chaetophoma* resembles a terrestrial fungus (fig. 2). It did indeed grow

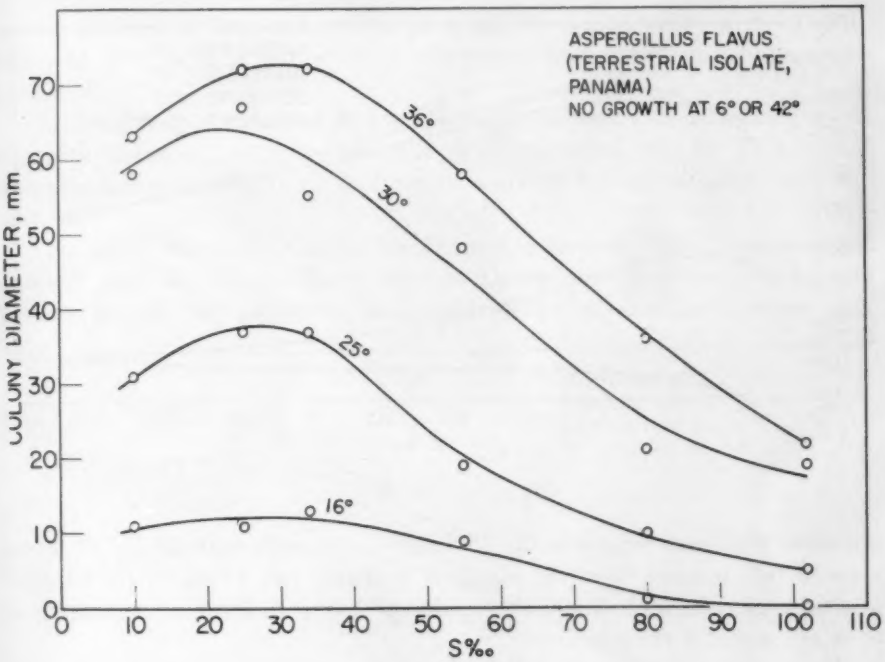

Fig. 1

faster at 33° C. in a medium resembling sea water (25–35 parts per thousand) than it did in weakly saline media (10 parts per thousand). But at 25° C., increasing salt concentration caused a steady decrease in growth rate, and that this organism does not follow a regular pattern becomes

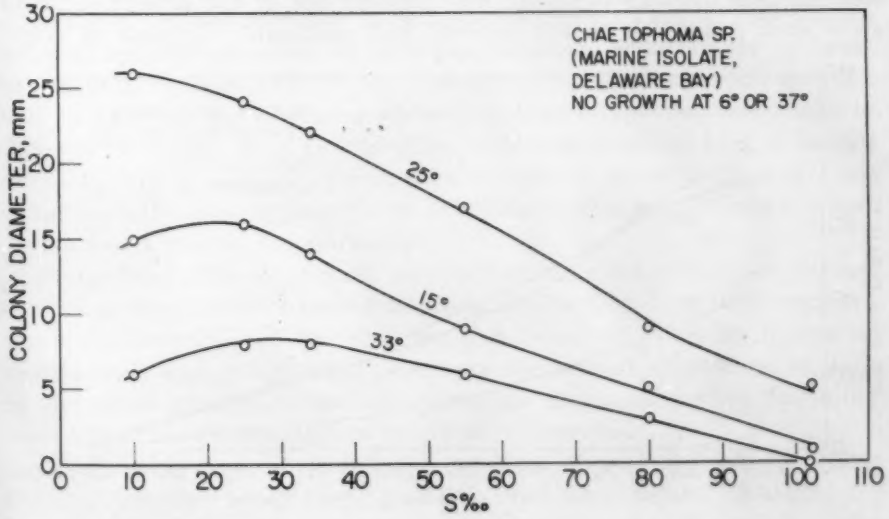

Fig. 2

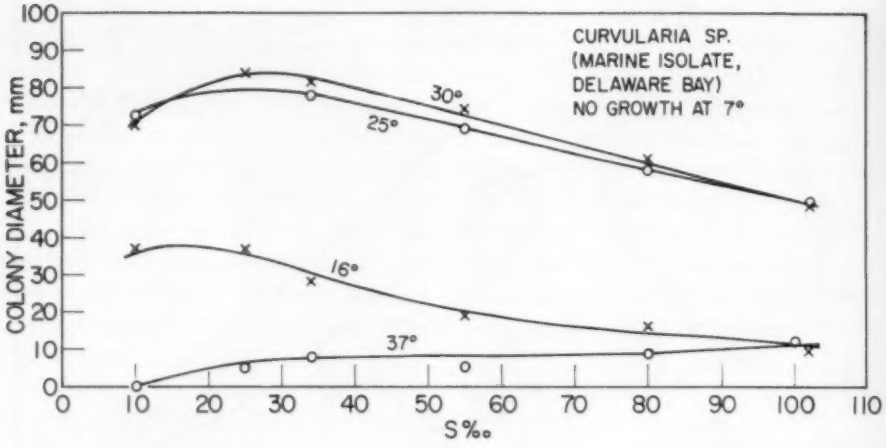

Fig. 3

apparent when one compares the 25-degree curve with that for 15° C. Thus, even though it came from the sea, it is probably not a completely adapted marine organism, and should be capable of living in fresh or sea water or in a non-aquatic environment.

Curvularia, in contrast, followed the *Phoma* pattern, in that it grew better in a low salinity medium when the temperature was low, and showed a graded series of results through intermediate temperatures and salinities until the maximum temperature of 37° C. was reached, at which point it grew better in the more concentrated salt medium than it did in the weaker solution (fig. 3). This organism was the only one of the present series to show such a reaction to the experimental treatment. Though it might

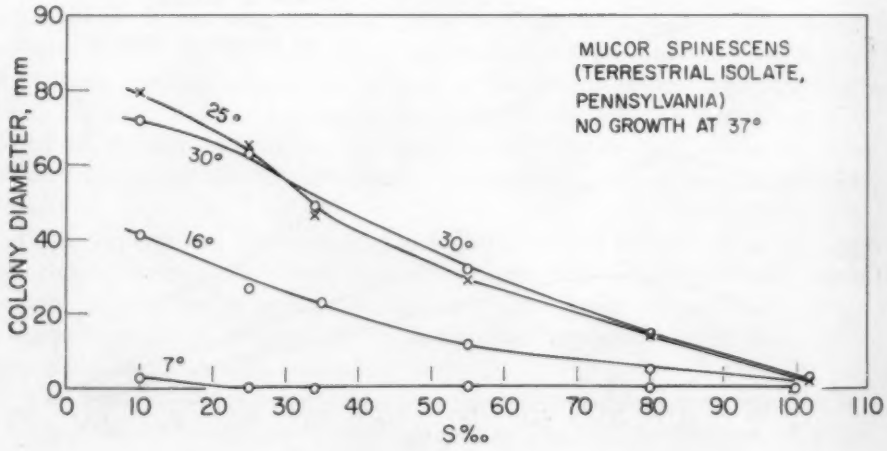

Fig. 4

survive in fresh or brackish water, provided the temperature were correct, it should grow best in salt water. It is apparently a well-adapted marine form.

The temperate, terrestrial *Mucor spinescens* showed a decrease in growth rate with increasing salinity regardless of temperature (fig. 4). This isolate is clearly a non-marine form, and would scarcely tolerate a saline environment.

The *Helicoma* from Vancouver showed a growth habit intermediate between that of the distinctly marine *Curvularia* and the non-marine *Mucor* (fig. 5). At moderate temperatures, a temperature increase was

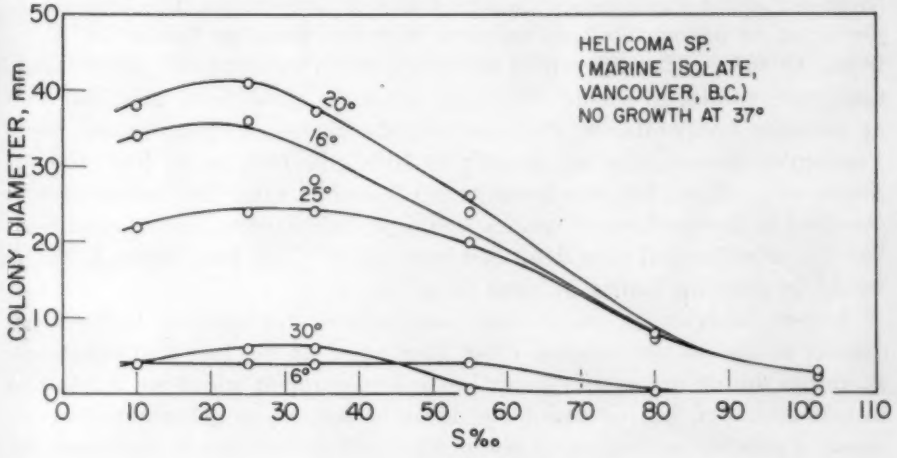

Fig. 5

accompanied by an increase in salinity tolerance. Thus at 16° C., the optimum salinity was about 20 parts per thousand; at 20° C, the optimum was about 25; and at 25°, it was up to about 30. But the pattern does not hold at extreme temperatures, where the *Phoma*-type reaction could be expected to appear most clearly. This *Helicoma* possesses only a limited ability to shift its salinity optima, even though the genus is not a rare one in marine collections. It seems to be in a state of transition between a non-marine and a strictly halophilic habit.

Fungi from different climates and habitats thus differ from one another as much in their temperature-salinity relations as they do in other respects. One might have guessed that this would be true, but fungi are in general so adaptable, and, in the types chosen for the present experiment at least, so tolerant of great environmental variation, that a theoretical possibility existed that the *Phoma* pattern might be widespread.

Gold (1959) has approached this problem by counting his collections of fungi from waters of varying salinity and temperature. Some of the fungi he found did not show any distribution pattern, but some did; and

those which did showed a pattern such as would be expected from a *Phoma* or a *Curvularia*. Gold's *Trichocladium* appeared in brackish water during cold weather, but in saltier water as the warm season advanced. The evidence from nature fits in with the evidence from artificial cultures.

The answer to our original question now appears. The *Phoma* pattern may occur in modified form in strains which were not obtained from the sea (e.g., *Aspergillus*). But it is not universal in salt-water collections (e.g., *Chaetophoma*), and is not even approached in some terrestrial forms (e.g., *Mucor*).

An additional point in connection with the geographical distribution of these particular fungi concerns their temperature optima. The tropical *A. flavus*, at its optimum salinities, grew over five times as fast at 36° C. as it did at 16° C. The differences between growth rates of the three warm-temperate species in the 16–30° range were not great, and none did well at extreme temperatures. But the slightly more northern isolate from Vancouver showed excellent growth at 16° C. In fact, at its best, the 16-degree rate was six times as great as the 30-degree rate. The fastest growth observed in this cool-water species would probably occur, under conditions like the experimental ones described here, at 20° C. or less, while *A. flavus* would be growing fastest at close to 36° C.

These observations, which may seem almost too obvious to mention, deserve notice for two reasons. First, they point up the fact that organisms in nature do not necessarily occur in the environment which we might like to call optimum, having based our ideas of optima on laboratory experiments. Probably no habitat exists in which all factors are at optimum for any one organism. Second, some common fungi appear in such a diversity of habitats that they are not infrequently thought of as practically ubiquitous, and relatively indifferent to climate. In the fungi considered here, the relation between temperature requirements and geographical latitude is as well defined as it is in higher plants.

I wish to thank Dr. Carl N. Shuster of the Delaware Marine Laboratory for the use of his laboratory and its facilities, and Dr. Samuel P. Meyers of the Marine Laboratory, University of Miami, for supplying the strain of *Helicoma* from British Columbia.

SUMMARY

1. For comparison with the growth habits of tropical marine fungi, five species of fungi were cultivated in a graded series of saline media at temperatures ranging from 6° C. to 42° C.

2. The organisms included a tropical terrestrial *Aspergillus*, two warm-temperate marine isolates (*Chaetophoma* and *Curvularia*), a temperate, terrestrial *Mucor*, and a cool-temperate marine *Helicoma*.

3. The experiments show that, of the species tested, only *Curvularia* clearly exhibits the so-called *Phoma* pattern, in which a low salinity must accompany low temperature, and a high salinity, a high temperature. *Helicoma* shows a partial adaptation to marine life. In general, the laboratory reactions of the diverse strains are indicative of their fitness for the habitats in which they were found.

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NEW YORK 27, NEW YORK

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NEW NORTH AMERICAN UMBELLIFERAE—III.

MILDRED E. MATHIAS AND LINCOLN CONSTANCE

Ligusticum Calderi, sp. nov. (fig. 1). Plantae perennes graciles (1–)3–7 dm. altae e caudice fibroso caulescentes inflorescentia scaberula puberulave excepta glabrae; lamina foliorum in ambitu ovato-deltoidea ternato-pinnata vel -bipinnata 5–20 cm. longa et alta, foliolis ovalibus vel lanceolatis pinnati-lobatis vel pinnatisectis; petioli scarioso-vaginantes 0.3–2.5 dm. longi; inflorescentiae umbella unica terminalis interdum pedunculis lateralbus suffulta; pedunculi terminales 0.5–3 dm. longi; bracteae involuerales inconspicuae vel nullae; radii 5–12 inaequales scaberuli puberulive 1–4 cm. longi; involucellae bracteolae paucae lineares lineari-lanceolataeve 3–12 mm. longae; pedicelli 6–10 mm. longi; flores albi vel rosei, petalis ovalibus vel oblanceolatis, stylis divaricatis 1.5–2 mm. longis, stylopodio conico; carpophorium filiforme; fructus ovoideo-oblongus glaber 6 mm. longus 3 mm. latus, costis suberoso-alatis; vittae parvae in intervallis 2 vel 3, in commissuris ca. 4; semina facie concava.

Plants perennial, (1–)3–7 dm. tall, glabrous except for the scaberulous and puberulent inflorescence and sometimes minutely scaberulous foliage, from a rooterown surmounting a taproot; basal leaves triangular-ovate, 5–20 cm. long and broad, ternate and 1–2-pinnate, the leaflets broadly oval to lanceolate, (0.7–)1–4 cm. long, 0.5–4.5 cm. broad, pinnately lobed to pinnatisect, with mucronulate, sometimes scaberulous-margined, linear-lanceolate ultimate divisions, glaucous beneath; cauline leaves few and like the basal, or reduced, or lacking; petioles 0.3–2.5 dm. long, abruptly dilated, broadly scarious-sheathing, and often purplish at base; inflorescence of a terminal and 1–3 smaller lateral umbels; terminal peduncle 0.5–3 dm. long; involuere of 1 or 2 linear bracts up to 2 cm. long, or leaflike, or lacking; rays 5–12, 1–4 cm. long, unequal, scaberulous or puberulent; involucel of 1–5(–7) linear or linear-lanceolate, green, ciliolulate bractlets 3–12 mm. long, shorter than to exceeding the flowers; mature pedicels 6–10 mm. long, scaberulous or puberulent; flowers white or pink, the calyx teeth obsolete, the petals oval to oblanceolate; mature styles 1.5–2 mm. long, divaricate, purplish, the stylopodium conical; carpophore filiform; fruit oblong-ovoid, 6 mm. long, 3 mm. broad, glabrous, the ribs corky-winged; vittae 2 or 3 in the intervals, about 4 on the commissure; seed face concave.

TYPE: *Calder & Taylor 23546*, rocky cliffs and talus slopes, 400–2000 feet altitude, Tasu Sound, head of Fairfax Inlet below Mount de la Touche, west coast of Moresby Island, Queen Charlotte Islands, British Columbia, Canada, 16–17 August 1957 (DAO 2781; UC-isotype).

DISTRIBUTION: Queen Charlotte Islands, British Columbia, rocky cliffs, open slopes, and edge of coniferous forests, from near sea level to 3400 feet elevation.

SPECIMENS EXAMINED: *Moresby Island*: Echo Harbour off Darwin Sound, 9-VII-1957, *Calder, Savile & Taylor 22351* (DAO); mountain at W. end of Mosquito Lake near head of Cumshewa Inlet, 24-VIII-1957, *Calder & Taylor 23690* (DAO); S. side of Buck Channel opposite Chaatl

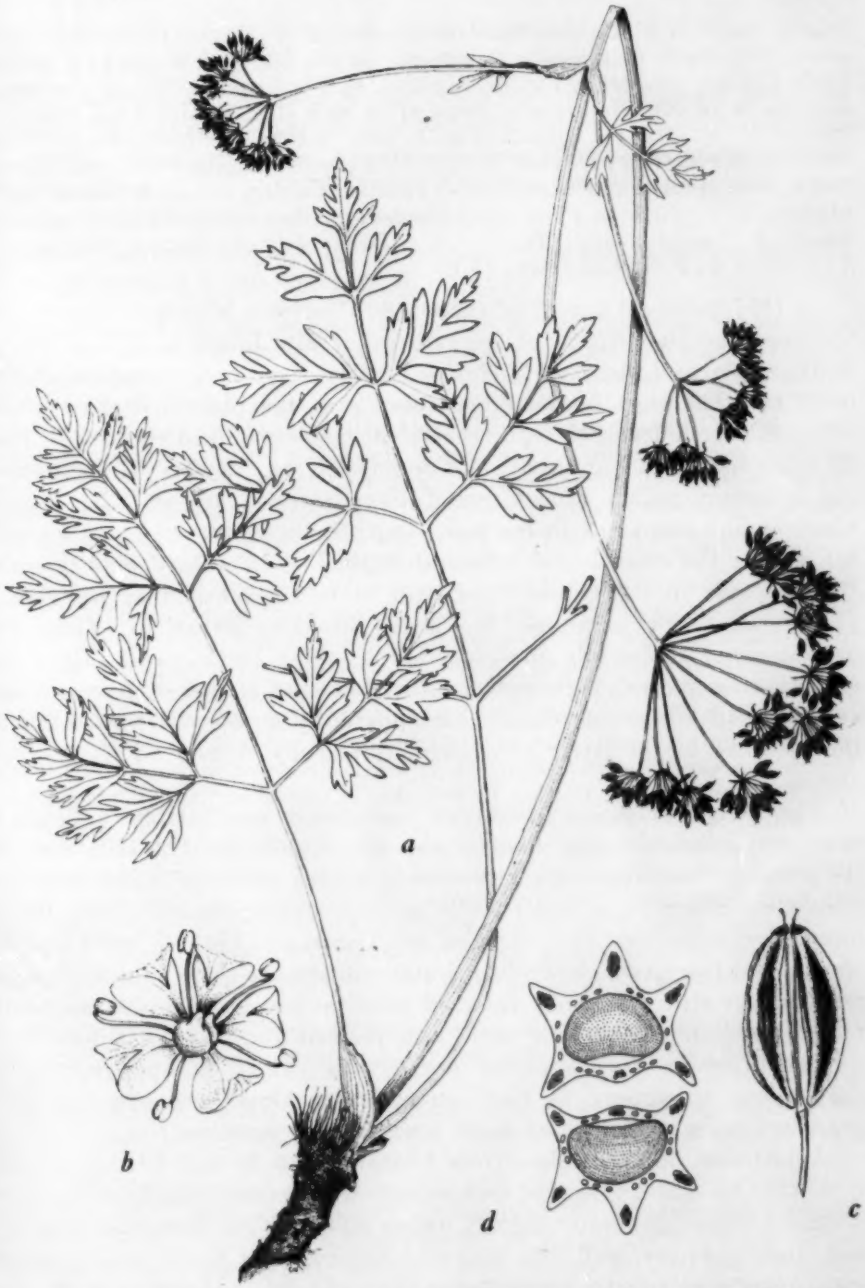

FIG. 1. *Ligusticum Calderi*. a. Habit, × ¼. b. Flower, × 8. c. Mature fruit, lateral view showing carpophore, × 4. d. Transection of mature fruit, × 6. (All from the type collection.)

Island, 24-VI-1957, *Calder, Savile & Taylor 21780* (DAO, UC); alpine area about 20 miles S. of Moresby Camp, 52° 55′ N, 132° 03′ W, 29-VII, 2-VIII-1957, *Calder, Savile & Taylor 23101* (DAO). *Graham Island:* mountain directly N. of Mt. Stapleton at head of Shields Bay, 9-VIII-1957, *Calder & Taylor 23380* (DAO); mountain on E. side at head of Shields Bay, 8-VIII-1957, *Calder & Taylor 23323* (DAO, UC); between Ells Point and Mercer Point, west Skidegate Channel, 25-VII-1957, *Calder, Savile & Taylor 22907* (DAO), UC); Newton Point, west Skidegate Channel, 25-VII-1957, *Calder, Savile & Taylor 22986* (DAO, UC). *Banks Island:* Larson Harbor, 19-VIII-1939, *T. T. McCabe 7353* (UC).

A 1957 botanical survey of the Queen Charlotte Islands, conducted for the Canadian Department of Agriculture by Mr. James A. Calder, Dr. D. B. O. Savile, and Mr. Roy L. Taylor, yielded some forty members of Umbelliferae. The most interesting of these was the plant described above, which attracted attention both because of its geographical remoteness from all other species of *Ligusticum* and because of the difficulty of distinguishing immature plants from those of *Conioselinum chinense* (L.) B.S.P., which is also abundant in the same area. In the course of checking with Mr. Calder the existence of a habitat distinction between *Ligusticum* and *Conioselinum* in the Queen Charlottes, it became clear that the former prefers alpine or subalpine, the latter shoreline situations. These two habitats come sufficiently close together in a few instances so that a few collections contained both genera. The flowering stages of *Conioselinum chinense* and *Ligusticum Calderi* are apparently most readily separable by the presence in the latter of a characteristically ligusticoid fibrous root crown.

The West American species of *Ligusticum* are notably difficult to characterize satisfactorily. Coulter and Rose (1900, pp. 129–140) credited the genus in North America with twenty species, eleven of which they had themselves described at one time or another, and appended a long list of unassigned collections. We (Mathias and Constance, 1944–45, pp. 143–148) transferred two species to *Podistera* and reduced the remaining eighteen to ten, but are still not wholly satisfied with the results. The distinguishing features appear to be mostly small and quantitative, making it difficult to construct precise and workable keys. Nevertheless, the populations of *Ligusticum* do appear to fall into fairly coherent morphological-geographical assemblages, which merit taxonomic recognition.

Ligusticum Calderi differs from *L. Grayi* C. & R. and *L. californicum* C. & R. by its scaberulous and puberulent inflorescence, usually more finely dissected foliage, generally slightly longer involucel bractlets, and narrower and slightly longer fruit. On the other hand, it is a much smaller plant, with fewer and smaller parts throughout, than *L. Canbyi* C. & R. and *L. Porteri* C. & R. There is a sharp geographical separation in each case, although *L. Canbyi* has now been collected in eastern British Columbia

(*Calder & Savile 9321, 11809*). No close relationship seems to exist, either, between *L. Calderi* and any Asiatic species of the genus.

Mr. Calder points out that all the collections of *Ligusticum* are from an area which exhibits "some degree of endemism in the mountains along the western coast of the Queen Charlotte Islands. There was undoubtedly a refugium there in the late Pleistocene. Both the ornithologists and mammalogists have strong supporting evidence. In my five years of field work in British Columbia this was the first time we had found an area of local endemism confined to the province."

Lomatium Frenchii, sp. nov. (fig. 2). Plantae glabrae aculescentes 1.5–2.5 dm. altae e radice elongata tuberosa; lamina foliorum ovata vel ovata-lanceolata 3.5–6 cm. longa 1–5 cm. lata bipinnatisecta divisionibus ultimis linearibus 1–4 mm. longis; petioli 5–12 cm. longi late scarioso-vaginantes; pedunculi folia excedentes 10–18 cm. longi; radii fertiles 2–5 valde inaequales patentes 0.5–4 cm. longi; involucella discoidea scariosa quam flores brevior diametro 3–5 mm.; umbellularum flores 10–20 lutei; pedicelli breves 1–2 mm. longi; fractus glaber ovatus apice basique acutus 8–10 mm. longus 3–4 mm. latus, alis quam corpore multo augustioribus; vittae minimae in intervallis 2–4, in commissura 6.

Plants perennial, acaulescent or subcaulescent with a prominent pseudoscape, 1.5–2.5 dm. high from a stout, napiform, vertical taproot, glabrous (rarely pubescent?); leaves ovate to ovate-lanceolate, the blade 3.5–6 cm. long, 1–5 cm. broad, bipinnatisect, the ultimate divisions linear, 1–4 mm. long, obtuse; petioles 5–12 cm. long, broadly scarious-sheathing nearly to the summit: peduncles one to several, 10–18 cm. long, exceeding the leaves; fertile rays 2–5, 0.5–4 cm. long, spreading, very unequal; involucel of several ovate to obovate, green-centered, scarious-margined bractlets united to or nearly to their tips into a complete or partial toothed disk 3–5 mm. in diameter, shorter than the flowers; umbellets 10–20-flowered; petals yellow, oval; calyx teeth minute; styles ca. 1 mm. long, spreading; pedicels 1–2 mm. long; fruit ovate, 8–10 mm. long, 3–4 mm. broad, tapering slightly at both apex and base, glabrous, the wings thin, much narrower than the body; vittae very small, 2–4 in the intervals, 6 on the commissure.

TYPE: *French 640*, rocky open flat about 1 mile NW. of Mill Creek, Warm Springs Indian Reservation, Jefferson County, Oregon, 10 May 1953 (UC 1,199,507).

DISTRIBUTION: Warm Springs Indian Reservation, southern Wasco and northern Jefferson counties of central Oregon, in dry, rocky, open habitats.

SPECIMENS EXAMINED: Jefferson Co.: S. of Highway 26, just W. of Mill Creek, 10-V-1953, French *640;* Sidwalter Flat, ca. 1 mile NW. of Mill Creek, 15-IV-1956. *1681.* Wasco Co.: W. of Highway 26 ca. 0.8 mile W. of Mill Creek bridge, Sidwalter (or Mill Creek) Flat, 3-V-1958. *1758, 1759, 1761 1762, 1770*; 3.3 miles W. of Highway 26, E. of Boulder Corral, 3-V-1958, *1775*; 1 mile W. of Highway 26, 24-V-1958, *1815*; 1 mile W. of Highway 26 ca. 0.8 mile NW. of Mill Creek bridge, 21-III-1959, *1870*; 3.5 miles W. of Highway 26 on road paralleling county line, 21-III-1959, *1872, 1873.*

a
b
c
d
e

Despite a superficial resemblance to *Lomatium leptocarpum* (T. & G.) C. & R. and *L. caruifolium* (H. & A.) C. & R., the plants just described seem to belong with the "tuberous" species *L. Cous* (S. Wats.) C. & R., *L. montanum* C. & R., and *L. circumdatum* C. & R., which are themselves none too clearly defined. From this trio, *L. Frenchii* differs in its more elongate root, more prominent pseudoscape, bipinnatisect rather than ternate-pinnatisect leaves, fewer rays, shorter pedicels, and almost completely connate, scarious involucel. The collection, *French 1873*, comprises several plants, selected from among normal glabrous ones, with some pubescence on the foliage and a single very immature plant with a few pubescent ovaries. This last observation calls attention to the similarity of the involucel in our new taxon to that of *L. Watsoni* C. & R. However, on the basis of the few sheets available for comparison, *L. Watsoni* is a much smaller and more delicate plant in all structures, with a well defined oblong tuber, and a characteristic pubescence of foliage and inflorescence in a group of species in which the last feature has at least been supposed to be a diagnostic character of considerable importance.

Dr. David French, who is Professor of Anthropology at Reed College, Portland, Oregon, has made many hundreds of collections of plant species in his studies of the ethnoscience of the Wasco, Warm Springs, Sahaptin, and Paiute Indians of Oregon. In his prosecution of ethnobotany, he has become an extremely competent observer of the Umbelliferae of the area, in which he has detected more than forty-five different representatives of the family.

Lomatium Ravenii, sp. nov. (fig. 3). Plantae villosae acaulescentes 1.5–4 dm. altae e caudice ramoso; lamina foliorum oblonga vel oblongo-ovalis, 4–10 cm. longa, 2.5 cm. lata ternato-bipinnata vel tri- vel bipinnatisecta divisionibus ultimis linearibus 1–4 mm. longis; petioli 2–10 cm. longi, late scariosi vel scarioso-vaginantes; pedunculi folia excedentes 10–30 cm. longi; radii fertiles 5–18 valde inaequales patenti-adscentes 2–7 cm. longi; involucellae bracteolae scariosae vel scarioso-marginatae lineares villosae vel ciliolatae, quam flores breviores 2–4 mm. longae; umbellularum flores 20–30 albi; antherae purpureae; pedicelli graciles 5–10 mm. longi; fructus villosus vel glabratus apice basique obtusus 6–8 mm. longus 4–7 mm. latus, alis quam corpore multo angustioribus; vittae maximae in intervallis 1 vel 2, in commissura usque ad 4.

Plants perennial, acaulescent, 1.5–4 dm. high, strongly *Apium*-scented, from a deep-seated, usually branched caudex, villous; leaves oblong to oblong-oval, 4–10 cm. long, 2–5 cm. broad, ternate-bipinnate or 2- or 3-pinnatisect, the ultimate divisions linear, 1–4 mm. long, acute, mucronulate; petioles 2–10 cm. long, broadly scarious-sheathing about to the middle;

FIG. 2. *Lomatium Frenchii.* a. Habit, × ½. b. Flowering umbellet, × 2. c. Petal, × 12. d. Mature fruit, showing dorsal and commissural surfaces of carpels, and carpophore, × 2. e Transection of mature carpel, × 8. (a, from *French 640;* b, c, from *1681;* d, e, from *1815.*)

peduncles one to several, 10–30 cm. long, exceeding the leaves; fertile rays 5–18, 2–7 cm. long. spreading-ascending, very unequal; involucel of several linear, scarious or scarious-margined, sparsely villous or at least ciliolulate, distinct bractlets 2–4 mm. long, shorter than the flowers; umbellets 20–30-flowered; petals white, obovate, glabrous; calyx teeth evident, ovate; anthers purple; styles ca. 1 mm. long, spreading; ovaries densely villous; pedicels 5–10 mm. long; fruit oval, 6–8 mm. long, 4–7 mm. broad, rounded at both ends, villous to glabrate, the wings thin, much narrower than the body; vittae large and prominent, 1 or 2 in the intervals, usually 4 on the commissure.

TYPE: *Constance & Bacigalupi 3672*, open, slightly alkaline flat with *Artemisia, Blepharipappus, Cryptantha,* and *Eriogonum,* 1 mile S. of Ravendale altitude 4800 feet, Lassen County, California, 14 June 1959. (UC 1,199,508).

DISTRIBUTION: Known only from the area of the type locality.

SPECIMENS EXAMINED: Lassen Co.: alkali mud flat with *Artemisia,* 2 miles S. of Ravendale, 24-VI-1935, *Keck & Clausen 3738* (UC); on adobe flats along U. S. Highway 395, 1.8 miles S. of Ravendale, 17-VI-1958, *Raven & Solbrig 13287* (UC, LA).

Lomatium Ravenii belongs to the group of species with decompound leaves, acaulescent habit, and pubescent ovaries, and seems to be related most specifically to *L. MacDougali* C. & R. and *L. nevadense* (S. Wats.) C. & R. Both of these two latter species occur in or near the general area of *L. Ravenii,* likewise in dry or desert habitats and frequently in company with *Artemisia.* From *L. MacDougali,* the new taxon differs principally in its white flowers with bright purple anthers (rather than yellow petals and anthers) and in its considerably less densely villous herbage. From *L. nevadense,* itself a markedly variable species, *L. Ravenii* is distinguishable by its much more highly dissected foliage and narrower ultimate leaf-divisions, villous involucel of distinct bractlets, and fewer vittae in the fruit. In both comparisons, the difference in appearance is much more striking than the listing of characters would indicate.

Although our new plant appears sharply distinct in both herbarium and field, it is not easy to find characters to separate it precisely from *L. MacDougali* and *L. nevadense.* It is even conceivable that a chance union of individuals of these two species might have yielded progeny, some of which found a hospitable environment in the slightly alkaline sagebrush of eastern Lassen County. The range of *L. Ravenii* beyond the area of the type locality is uncertain. A few sheets culled from folders of *L. MacDougali* and *L. nevadense* in the University of California Herbarium (e. g., *Cusick 2372, Maguire & Holmgren 26409, Peck 20636*) suggest that *L.*

Fig. 3. *Lomatium Ravenii.* a Habit, × ½, b. Flowering umbellet, × 3. c. Transection of mature fruit, × 6. d. Mature fruit, showing commissural and dorsal surfaces of carpels, and carpophore, × 3. (a, b, and d, from *Raven & Solbrig 13287;* c, from the type collection.)

a
b
c
d

Ravenii, or something very similar, may occur also in Harney and Malheur counties of southeastern Oregon, a suggestion that needs to be followed up by field study.

We take pleasure in dedicating the new taxon to Mr. Peter H. Raven, who has long taken a most helpful interest in our work with Umbelliferae. It was his 1958 collection, with Dr. Otto T. Solbrig, of the plant which brought it to our attention, and led to the "rediscovery" of that of Keck and Clausen. The junior author made a special trip to the Ravendale area to study the plant *in situ*; even though 1959 has been a most unfavorable (dry) year, it was possible to collect *Lomatium Ravenii* in some quantity. The new collection has been designated as the type because it is possible to give it a wider distribution than any of the earlier ones.

The writers have not failed to notice that a number of the taxa of *Lomatium* described by them, as well as of those described earlier by Coulter and Rose, consist of well marked and relatively uniform but decidedly local populations. These are characterized by strikingly unique assemblages of features of leaf division, pubescence, involucel, flower color, etc., that occur individually in other known species of the same region. Little is known of the breeding systems operative in this genus, except that polyploidy does occur (Bell & Constance, 1958); we have been unsuccessful thus far in obtaining chromosome counts on *L. Ravenii* and *L. Frenchii*. There appears to be growing evidence of some kind of recombination of characters in self-perpetuating "intermediate" populations.

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THE FREEZE-DRYING OF PINE POLLEN

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The freeze-drying of pollen has received little attention compared to the lyophilization of other biological material. Pfeiffer (1955) lyophilized the pollen of three species and three hybrids of *Lilium*, and stored them in a vacuum for 50–194 days at – 20° C., 5° C., and room temperature. She found that pollen stored at the same temperature, with a relative humidity of 35 per cent or less had better germination than did the lyophilized samples. The attempted lyophilization of pine pollen by Hesseltine and Snyder (1958), using filtered bovine serum, with modifications, as a suspension agent, was unsuccessful.

The tests reported here on the freeze-drying of pine pollen are a portion of more extensive, and continuing, investigations on freeze-drying as a basis for the preservation of pollens of agricultural crops for long-period storage and long-distance shipment. Only certain series of the 1959 pine pollen experiments, furthermore, are included here. The remaining series will continue in storage for some months to come.

Materials and methods. Only the pollen of loblolly pine (*Pinus Taeda* L.) was used in these preliminary tests; however, since species differences are to be expected in the reactions of pollens to artificial environmental conditions, the pollens of other commercial pine species should be similarly tested.

Freeze-drying was carried out in a Virtis freeze-dryer, with no pretreatment of the pollen. A test series consisted of the following exposures of the pollen to freeze-drying action: One, five, ten, 15 and 30 minutes; and one, three, five, and seven hours. Each tear drying bulb contained one-tenth to one-twelfth gram of pollen. Excessive pollen usually was sucked into the vacuum chamber of the apparatus. Usually two samples were included for each time of exposure; and in the first test series run on loblolly pine pollen, one of the samples for each exposure was tested immediately for viability after being freeze-dried. It was determined in this way that the pollen would survive freeze-drying for various periods of time. Each bulb of pollen in every series of tests, thereafter, had to be clamped off from the action of the apparatus when the sample's specific exposure time had lapsed. All clamps were removed at the end of a freeze-dry series run, and the vacuum in the

[1] Appreciation is expressed for the assistance of Mr. V. N. Madhava Rao, Banana Research Officer, Coimbatore Agri. College and Research Institute, Madras, India, on leave to the U. S. for graduate studies.

TABLE 1. *The effect on viability of loblolly pine pollen of different time exposures to freeze-drying.*

Time of Exposure to freeze-drying	Percentage of germination[2]
1 min.	73
5 "	99
10 "	91
15 "	80
30 "	93
1 hr.	91
3 hrs.	89
5 "	60
Control	85

[2] Pollen was cultured immediately following removal from port of freeze-dryer.

freeze-dryer was replaced with nitrogen gas. Each bulb was then torch-sealed while still inserted in its port on the freeze-dryer. The bulbs of one particular series were vacuum sealed, even though previous freeze-drying experiments with other pollens in 1958 had shown unsatisfactory storage in vacuum.

All sealed, nitrogen filled, bulbs were kept in the uncontrolled environment of the laboratory, with the exception of those of one series. The latter were distributed among three temperatures—5° C., −30° C., and −65° C. The series of vacuum sealed bulbs was stored at 5° C. Control samples of pollen at the three low temperatures were in corked vials.

Viability was tested by germination in .7 per cent agar—10 per cent sucrose (according to Hesseltine and Snyder 1958) in a moist chamber at room temperature and humidity. Estimates of viability were based on two counts of 100 grains each after the pollen had been cultured for at least 96 hours. Comparisons between germination of grains in distilled water and germination on nutrient agar medium showed, in general, more rapid germination and higher germination percentage in the latter.

Results and discussion. The results, thus far, of three preliminary tests on the freeze-drying of loblolly pine pollen as shown in Tables 1, 2 and 3

TABLE 2. *The effect on viability of loblolly pine pollen of vacuum storage at 5° C.*[3] *after freeze-dry treatment.*

Time of Exposure to freeze-drying	Percentage of germination
1 min.	88
5 "	86
10 "	86
15 "	88
30 "	81
1 hr.	85
3 hrs.	29
5 "	72
Control (stored at 5° C.)	74

[3] Storage in vacuum at 5° C. was for 74 days.

leave no doubt that this pollen will maintain a high per cent of its viability even under uncontrolled environmental conditions for a prolonged period following freeze-drying and storage in nitrogen gas. It remains to be determined from tests still in progress as to how long viability can be maintained under such conditions and as to what effect the added environmental condition of low temperature will have.

Pollens are specific in their responses to changes in the environment, so that only after tests similar to those described above have been run, can it be said as to whether pollen of other pine species can also be freeze-dried and stored in nitrogen gas, or in a similar storage environment.

TABLE 3. *The effect on viability of loblolly pine pollen of storage in Nitrogen gas at room temperature and humidity after freeze-dry treatment.*

Time of Exposure[4] to freeze-dry	Viability at Collection[5] (percentage)	Days of Storage in N_2 at room T/RH	Viability percentage after storage	
			Cultured immed.	Cultured after 48 hrs. at 5° C., 60% R.H.
5 min.	80	51	61	63
30 min.	80	51	29	88
30 min.[6]	80	86	23	79
1 hr.	80	54	0	66
1 hr.[7]	80	99	0	70
3 hrs.	80	54	0	60
4 hrs.	80	51	10	53
7 hrs.	80	54	0	40

[4] Samples at exposures of 1, 10, and 15 minutes have not yet been opened.
[5] Control samples had 0% germination in 18 to 31 days at room temperature and humidity.
[6,7] These samples were shipped to New Zealand and Brazil, respectively.

These tests are indicating, so far, that there is a rather wide range of tolerance of loblolly pine pollen to freeze-drying (Table 1); but the erratic responses of pollen, by germination, to an artificial environment must be considered (as indicated in Tables 1, 2, and 3) when the amount of viability is estimated on the basis of germination percentages. It should be noted, furthermore, that germination was usually much higher after pollen had been kept in a household refrigerator (at 5° C. and 60% R. H.) for one or more days following release from nitrogen gas storage (Table 3). This so-called rehydration, or humidification, has been reported for other pollens, following storage at low humidities (Duffield & Snow 1941, Pfeiffer 1955).

It can only be postulated at the present time that temperature was a greater factor in the maintenance of viability in vacuum storage of loblolly pine pollen (Table 2) than was the vacuum environment of the pollen. The viability of the control sample at the same temperature was also high (74 per cent germination), while previous treatments of other pollens with

freeze-dry and storage in vacuum were unsatisfactory (King, unpublished data). It was not intended during the course of these tests to compare vacuum storage with other environments, such as nitrogen; but after the series of vacuum stored pollens was tested for viability (Table 2), it was obvious that such a comparison would be advisable for pine pollen in the future.

The maintenance of pollen viability in a light weight sealed container, and in an otherwise uncontrolled environment, is of particular advantage in the long-distance shipment of pollens. Such shipments today require costly packaging and special precautions for maintaining viability enroute. Loblolly pine pollen was shipped to New Zealand and return and to Brazil and return, unopened.[8] Each sample, packed in "Starfoam," weighed slightly over one ounce when shipped, and each had lain on a laboratory shelf for nearly two months before shipment. Both packages, and their enclosed pollen samples, returned in excellent condition, having been enroute 26 and 39 days respectively (Table 3).

The future value of freeze-drying in the preservation, and long-distance shipment, of pine pollens will rest not only on improved techniques but also on the realization that the pollen of each plant species usually reacts specifically to changes in its environment, and should, consequently, be studied individually.

SUMMARY

Pollen of loblolly pine (*Pinus Taeda* L.) has a wide tolerance for the action of freeze-drying. Samples have, thus far, in these preliminary tests maintained their viability sealed in nitrogen gas, following freeze-dry treatment, up to 99 days in an otherwise uncontrolled environment.

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[8] Appreciation is expressed for the cooperation in these shipments of Mr. Daniel E. Brady and Mr. Ford M. Milam, the Agricultural Attaches in the American Embassies in Wellington, N. Z. and Rio de Janeiro, Brazil, respectively.

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CYTOLOGICAL OBSERVATIONS ON THE PRODUCTION OF ANTHOCYANINS IN CERTAIN SOLANACEAE

JOHN POLITIS

In 1911 the author began to study the formation of anthocyanin pigments in plant cells, which up to that time was practically unknown. The results of his investigations based on the examination of large numbers of flowers, belonging to different genera, were summarized and published (1911 and 1914).

It was shown that the anthocyanin pigments in certain flowers appear first in the cytoplasm inside special corpuscles which have been designated as cyanoplasts (1914). In examining the microchemical reactions and development of these corpuscles, it was found that they have an envelope in the interior of which a colorless phenolic compound is produced which eventually is transformed into anthocyanin. Guillermond (1913 a & b, 1914 & 1933) confirmed our findings.

Lipmaa (1926) working with the flowers of *Erythraea* showed that the anthocyanin pigment is located in the epidermal cells within special bodies, one in each cell and, apparently unaware of our publication, he called them anthocyanophores.

Solereder in 1916 reported the formation of anthocyanin pigments in the petioles of leaves of *Cyanastrum cordifolium* Oliv. Upon examining the leaf stalks with a hand lens he was very much impressed by the presence of black spots in the lower parts of the stalks. Each sub-epidermal cell within these spots contains besides the numerous chloroplasts a single spherical anthocyanin body of indigo blue color. I believe that these bodies belong to the category of corpuscles which I have studied and named cyanoplasts.

The results on the subject published up to the present show that cyanoplasts can be found within some flowers, leaves and fruits.

Continuing these investigations, the writer's attention has been directed mainly to the mode of formation of anthocyanin pigments produced in very young plants, a few days after the germination of seeds.

The results of my research on the cyanoplasts of *Raphanus sativus* were communicated in the Academy of Science in Paris (1942). The present study deals with the formation of anthocyanin in the flowers of *Hyoscyamus niger* and in young plants of different species of *Solanaceae*.

Hyoscyamus niger L. In studying this plant the presence of cyanoplasts within the cells of the floral parts and also in other parts of the young

plants was noticed. In examining the flowers during their final stages of development, it was noted that the style and filaments of the stamens manifest the presence of a violet color, while certain parts of the corolla are purple. These colored parts consist of cells containing anthocyanin dissolved, for the most part, within the cell sap. However, cyanoplasts were observed in certain cells and especially in those of the style.

In order that the development of the cyanoplasts may be observed it is necessary that young flowers be examined during certain period of their development, just as the formation of anthocyanin commences. The formation of the coloring substance is connected with the presence of cyanoplasts since only cells containing cyanoplasts have the above mentioned coloring. The development of cyanoplasts has been studied in the corolla tube, in the style and in the filaments of stamens of unopened flowers.

When examining the inner part of the corolla tube of such flowers one can observe that certain cells contain violet colored spherical cyanoplasts. In the cell, when the sap is as yet colorless, an extremely small spherical body can be seen (fig. 1). At first, this body is colorless and exhibits a strong brownian movement, which gradually decreases and finally ceases. At the same time the spherical body increases in size and within it appears a violet coloring substance, at the beginning rather weak, but becoming much more intense at its final development, when it may attain a greater size than that of the nucleus.

At the same time that this body enlarges and becomes colored, the cell sap, which at the beginning was completely colorless, begins to show a weak color which becomes gradually stronger due to the presence of a coloring substance answering to all the characteristic reactions of anthocyanins. In the neighborhood of the anthocyanin containing cells there are other cells without any coloring matter. These cells are devoid of the described bodies, the presence of which seems indispensable for the formation of anthocyanin in these flowers.

The styles of young flowers were examined when they were very young. At this stage of their development, the styles are colorless while the stigmas are slightly colored. This stage is most favorable for the study of the cyanoplast development. In examining the cells of the style it was observed that every cell contains an abundant amount of protoplasm, and within it many leucoplasts, a spherical nucleus and, near it, an extremely small body distinguished from the leucoplasts by its oily appearance and its exhibition of brownian movement (fig. 2).

This body which is located inside a small vacuole gradually increases in size till it attains or exceeds the size of the nucleus. It develops a violet color and finally disappears. The fully developed cells of the styles of open flowers contain, therefore, only a violet colored sap and are devoid of the

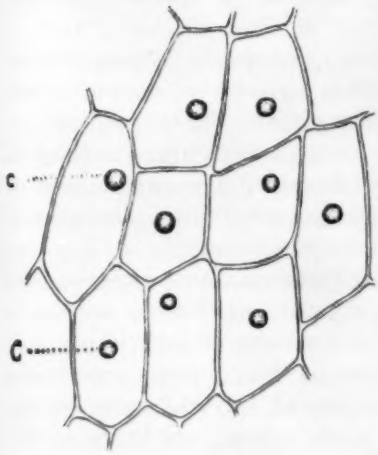

Fig. 1

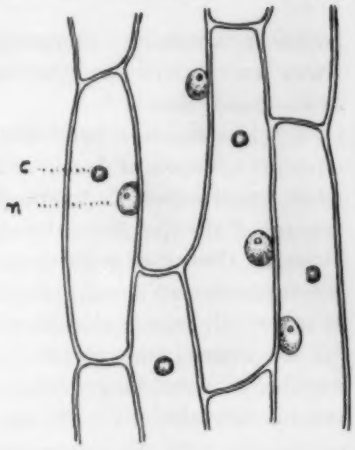

Fig. 2.

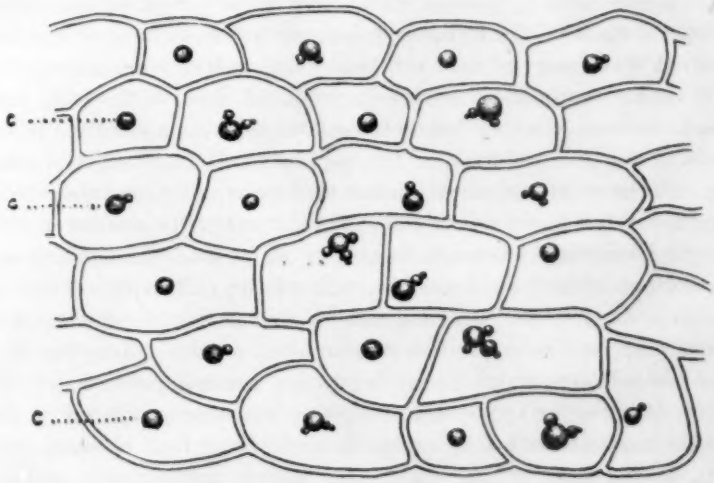

Fig. 3.

FIG. 1.—Epidermal cells from the petals of *Hyoscyamus niger* each containing one cyanoplast (c). FIG. 2.—Epidermal cells from the style of *Hyoscyamus niger*, each containing one cyanoplast (c) and one nucleus (n). FIG. 3.—Hypodermal cells of *Brassica oleracea* v. *Botrytis* (broccoli) containing cyanoplasts (c) some of which divide through budding.

bodies in which the color originated. The color substance is soluble in both water and alcohol. In reacting with acids it becomes red and with alkalies (ammonia) blue.

By treating free hand sections of the styles of unopened flowers with an aqueous solution of ferric chloride, the colorless bodies were stained green, while caustic potash or ammonia stained them yellow. These reactions are typical of the flavonic substances from which the anthocyanins are formed. It would therefore seem clear that the bodies described here are the seat of the formation of flavonic substances which are converted into anthocyanins. It is for this reason that they have been named cyanoplasts.

The above mentioned facts as well as other facts connected with the production of some other substances within the plant cell, led the author to certain speculations with regard to the subject matter of inheritance and of the role that the genes may play. The color of flowers is an inheritable character. In order to explain the transmission of this character to the progeny we believe, that some product of genic action, which comes out from the nucleus, changes into a cyanoplast which has the ability to produce anthocyanin.

Solanum Lycopersicum, Linn. From the numerous varieties of this plant we examined the variety Marglobe. In young plants of this variety grown in a place exposed to the sun it was ascertained that a majority of them have a red-violet hypocotyl due to the presence of anthocyanin. If a longitudinal section of the hypocotyl is made a few days after germination of the seed it was observed that the epidermal cells are elongated, they are devoid of anthocyanin, their nucleus is situated close to the wall and close to the nucleus there are tiny leucoplasts. The coloring substance is situated in the cells under the epidermis of the hypocotyl. The cyanoplasts are found in young cells as small spherical bodies without a coloring substance. They enlarge, gradually become colored and at their maturity assume a red-violet color due to a coloring substance soluble in water and alcohol and showing all the reactions of anthocyanins. In each of the cells appears one cyanoplast, having an involucre, which shows characteristic resistance to the above dissolving media. After the development of the cyanoplast it disappears and the cell sap, which in the beginning was colorless, assumes a red-violet color. Besides the hypocotyl anthocyanin is also produced at the base of the main vein of each cotyledon. A vertical section through a young cotyledon, at the base of the main vein shows that certain parenchyma cells, situated below the lower epidermis, during their youth contain cyanoplasts of which in its full development has a size similar or somewhat greater than that of the nucleus. It is spherical and has a red-violet color. These cyanoplasts through the reaction of diluted ammonia assume a blue color while with the reaction of diluted hydrochloric acid they assume a red color.

The cyanoplasts have the ability to grow and multiply through budding (fig. 3).

The seeds were sown at the beginning of April and the examination of the young plants was made at the end of the month, when the hypocotyl had a length of 8–10 cm. and the cotyledons were much shorter.

We have found cyanoplasts also in young plants of the following species: *Solanum sisymbrifolium*, Mam.—*Solanum racemosum*, Facq.

Datura inermis, Facq. The hypocotyl of young plants about 12 days old has a blue-violet color. By examining under the microscope a vertical section through the hypocotyl it can be ascertained that the epidermis is devoid of anthocyanin, is covered by a thin cuticle and besides the stomata it has glandular hairs. The anthocyanin is produced in cells situated under the epidermis. These cells contain, besides the nucleus and the chloroplasts, cyanoplasts. In each of these cells we can observe spherical bodies usually united in a cluster or forming a string of beads with or without branches. These bodies have a blue-violet color; in the beginning they are very few and small and then gradually enlarge and multiply. The multiplication seems to take place by budding. As the enlargement and the multiplication of these bodies take place, the sap of the cells which contain them, which in the beginning was completely colorless, begins gradually to assume a red-violet color. Finally as the cyanoplasts disappear the sap assumes a very strong red-violet color. The coloring substance of the cyanoplasts dissolves in water and in alcohol. With the use of these and other dissolving liquids it can be ascertained that the cyanoplasts have an involucre. With the use of diluted hydrochloric acid the coloring substance assumes a red color. The same coloring substance becomes green under the influence of ammonia or diluted solution of potassium hydroxide.

Examining both sides of the cotyledons we have observed that the lower side which is exposed to the influence of the sun light shows a red color. The lower side is exposed to the influence of sun light as are the cotyledons. During the germination of the seed and sometime afterward, the cotyledons continue to be kept together at their ends by the seed coat. Finally the seed coat falls off and the cotyledons assume their regular position. A cross section through the cotyledon when it emerges from the seed shows the upper epidermis, which covers a layer of palisadal cells the nuclei of which have a central position, 5–6 rows of parenchyma cells, the beginning of the veins and the lower epidermis. The cotyledons are entire, elongated in shape and contain oil and starch. On the upper side the color is green. On this side are found small glandular hairs which, like those of the hypocotyl, are colorless and consist of a long stalk consisting of one or two cells and a spherical head. The red-violet color of the under surface of the cotyledons is due to the presence of anthocyanin which is formed not only in the cells of the

lower epidermis but also in the cells which occur beneath this epidermis. In the latter cells, before the formation of anthocyanin and when the sap is still colorless, one can observe abundant protoplasm, a large spherical nucleus, chloroplasts and one or more red-violet spherical bodies. When there is one such body its size can reach or surpass the size of the nucleus. When there are more than one such body their size is smaller than the nucleus and usually they are found united. The development of these bodies and the production of red-violet anthocyanin in them can be followed especially in cells situated close to the beginnings of veins. This substance is formed in small spherical bodies which enlarge gradually and from the coloring substance produced in them, the cell sap assumes a red-violet color. Before the production of these bodies or in cells which are devoid of them, the cell sap remains colorless.

We have found cyanoplasts also in young plants of the following species: *Datura Wrightii*, Hort., *Datura Stramonium*, Wall.

SUMMARY

1. In the present paper the finding of cyanoplasts in the hypocotyl and the cotyledons of certain species of *Solanaceae* is described. The development of the cyanoplasts takes place as follows. Each of the cells under the epidermis during its earliest stage, encloses besides the nucleus and the chloroplasts an extremely small colorless spherical body having a brownian movement.

2. This body gradually increases in size, shows a red, violet or red-violet color, becomes larger than the nucleus, ceases to move and finally disappears.

3. During the time of the development of the body, the cell sap, which at first, is colorless, assumes a red, violet, or red-violet color. This is due to coloring substances which give all the microchemical reactions of anthocyanin.

4. The above mentioned facts as well as other facts connected with the production of some other substances within the plant cell, led the author to certain speculations with regard to the matter of inheritance and of the role that the genes may play. The cyanoplasts have the ability to grow and multiply through budding and often appear near the nucleus. This fact led us to the conclusion that some product of genic action comes out from the nucleus, changes into a cyanoplast and has the ability to produce anthocyanin. The same thing that we assumed for the production of anthocyanin, we can assume for the production of many other substances that are formed in the cell. This hypothesis for the first time was published in our paper "Immunité et hérédité chez les végétaux" (1940).

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STUDIES ON AMERICAN HEPATICAE. 9. A SUPPLEMENT TO "THE GENUS BAZZANIA IN CENTRAL AND SOUTH AMERICA." II. TRIDENTATAE (3)

MARGARET FULFORD[1,2]

SECTION 2. CONNATAE

Plants with leaves three-toothed (mostly entire in *B. schwaneckiana*), the margins usually serrulate to dentate in the apical part; the underleaves attached in a straight line and connate with the ventral base of *one* or a *pair* of leaves. (In poorly developed plants this is often not conspicuous except under high magnification.)

Note: Most of the species are highly variable or they integrade, so that one finds a wide range of forms to which it is difficult to assign names, and decisions are sometimes arbitrary.

KEY TO THE SPECIES

Underleaves connate by a few cells (often one or two) with one leaf only (always on the same side of a stem).
- Underleaves chlorophyllose throughout.
  - Underleaves entire or nearly so ..... 26. *B. fendleri*
  - Underleaves variously incised and toothed on the margins ..... 31. *B. cubensis*
- Underleaves with a border of hyaline cells.
  - Leaves conspicuously three-toothed, the margins strongly serrate and spinose ..... 30. *B. armatistipula*
  - Leaves conspicuously three-toothed, the margins obscurely serrulate ..... 29. *B. eggersiana*
  - Leaves inconspicuously three-toothed to truncate-undulate, the margins serrate and spinose ..... 28. *B. pycnophylla*
  - Leaves mostly rounded-entire, the apical margins only serrate ..... 27. *B. schwaneckiana*

Underleaves connate with a pair of leaves.
- Plants medium size to large, 2–3.5 mm broad, usually long, green becoming brownish; smaller plants light green to greenish-brown; leaves usually long, ascendant, becoming recurved to falcate from a broad base, the ventral margin always concave; the teeth long, slender, the margin serrate-dentate; cells of the apical portion mostly 22–24 μ long; the underleaves with a hyaline border, variously incised and lobed, the margin coarsely dentate to serrate, often recurved ..... 32. *B. peruviana*
- Plants medium size to small, to 2 mm broad; the leaves spreading to ascendant, the ventral margin mostly straight or convex, the teeth short slender, short spinose, or obscure, the apical margin more or less serrate.

[1] Work related to a project supported by National Science Grant no. G 2616.
[2] Illustrations published with the assistance of the Lucien M. Underwood Memorial Fund.

Plants small, delicate, light green, rarely becoming darker; the leaves spreading, with a suggestion of a vitta, the ventral margin convex; underleaves incised, strongly serrate-dentate, hyaline to one-third or more their length ..... (forms of) ..... 32. *B. peruviana*

Plants more or less brown, often strongly so; leaves ascendant, the ventral margin straight or nearly so, the teeth short to obscure, the apical margins more or less serrate, most cells of the apical region 27 μ or more in length; the underleaves mostly undivided (or with occasional broad shallow lobes or teeth), the margins entire or with a few serrations; hyaline cells absent or a few scattered along the margin, or more forming a narrow border ..... 33. *B. skottsbergii*

26. BAZZANIA FENDLERI (Steph.) Fulford.

Habitat: Not given.

Distribution: Venezuela: (original, FH, G).—Brazil.—Ecuador.

27. BAZZANIA SCHWANECKIANA (Hampe & Gottsche) Trevis.

Habitat: In depressed mats over logs and shaded banks.

Distribution: Puerto Rico: (original, YU, NY); add, without locality Schwanecke 19 (G); Luquillo Mountains, Sintenis 12 (G); Luquillo Mountains, Heller 4646, 4653, 4760 (MO).—Guadeloupe: add, without locality, l'Herminier 10, 11, 12, 32, 55 (G); without locality or collector, ex Hb. Barbey-Boissier, as *M. venezuelanum* var. *β* Molkenb. (G).—Dominica: add, Mt. Diablotin, Elliott 2123, 2174 (BM).—Martinique: add, without locality, Duss 38 (G).

28. BAZZANIA PYCNOPHYLLA (Taylor) Trevis.

Habitat: In depressed mats on logs and tree bases in woods.

Distribution: Jamaica: (original, FH, NY).—Puerto Rico: add, Luquillo Mountains, Heller, 4654 (MO).—Guadeloupe.

29. BAZZANIA EGGERSIANA (Steph.) Pagán.

Habitat: On logs and bases of trees, woods.

Distribution: Cuba: (original, FH, G).—Jamaica, s.w. of Ecclesdown, M. Farr 1151, 1199 (IJ).

30. BAZZANIA ARMATISTIPULA (Steph.) Fulford.

Habitat: In depressed mats over logs and on tree bases in woods.

Distribution: Cuba: add, Oriente, Sierra Maestra, Morton 9460a, 9461 (US).—Jamaica: (original, YU, FH, G); add, trail to Hardware Gap, M. Farr 865 (IJ); summit of Mt. Horeb, M. Farr 951 (IJ); Caledonia Peak, M. Farr 1008 p.p. (IJ); Hardware Gap to waterfall, M. Farr 1250 (IJ); Cuna Cuna, M. Farr 1335, 1337, 1340, 1341, 1343 p.p. (IJ).

31. BAZZANIA CUBENSIS (Gottsche) Pagán.

Habitat: On logs and bases of trees, woods.

Distribution: Cuba: (original, YU, NY, G); add, Oriente, Moa Region, Webster 812, 816 (Mich); Oriente, Sierra Maestra, Morton 9459 (US).—Jamaica.—Puerto Rico.

32. BAZZANIA PERUVIANA (Lehm. & Lindenb.) Trevis. Figures 79–83.

Mastigobryum lechleri Stephani, Hedw. **25**: 134. pl. 6. figs. 10–14. 1886.

add syn. *Mastigobryum cerinum* Stephani, Spec. Hepat. **3**: 457. 1908. syn. nov. [Stephani, Icones Hep., *Mastigobryum* no. 113.]

This species is characteristically a large to medium size plant with stems to 3.5 mm broad and dark green becoming brownish. The long stems bear

rather long, ascendant leaves which become decurved to falcate from a broad base (fig. 79). The ventral margin of the leaf is always concave and the three conspicuous teeth are long and slender, with the apical margin of the leaf more or less strongly serrate-dentate. Most of the cells of the apical part are 24μ long (fig. 80). The underleaves are large, longer than broad, often recurved above, with the margin incised-lobed to -toothed and serrate-dentate (fig. 79). There is a hyaline border of a few to several rows of cells and the number of rows varies even on one stem. Some of the smaller plants (*M. lechleri*), or small branches of more robust stems may be pale green, scarcely tinged with brown. The stems of these plants have spreading leaves which tend to be ovate in the basal part, with a convex ventral margin and shorter teeth and few serrations on the apical margin. Underleaves on these stems have a very broad hyaline border, and in some instances more than half the underleaf is hyaline. The differences between these stems and the characteristic robust plants is a striking one and the former might well be referred to a different species except that the two forms have been found on the same plants in unfavorable habitats.

The original material of *M. cerinum* is very much like the robust *B. peruviana* but differs in being smaller and more deeply pigmented with brown. The stems are 3–5 cm long, the bases of the leaves are broad and the ventral margins are concave (fig. 81). The less well developed plants from extreme habitats are very similar to *B. skottsbergii* (No. 33 following), and the two are difficult to separate.

Habitat: In depressed mats or ascending tufts on soil, rocks and the bases and trunks of trees.

Distribution: Brazil: S. Catarina, Reitz 2.354, poor (HBR).—Peru: without locality or collector, Hb. Gottsche, the original (FH); without locality, Jameson (NY).—Chile: Valdivia, Hahn 2, [2a] (G); the same, ex. Hb. Jack (FH, G); Valdivia, Lechler, the original of *M. lechleri* (FH, G); Valdivia: Arique, Lechler, *Plantae chil.* 681a (G); the same, 681a, as *M. novae-hollandiae* (G); Port Montt, Bro. Claude-Joseph 3216 (YU); Corral, Thaxter 142, 149, 7913 (YU, FH), 20, 98 (MICH); Curicó, Wollemeyer 279a (FH); without locality, H. C. Lorenz (NY); without locality, Cuming (G); without locality, Dusén 355, as *M. cerinum* (G); without locality, Skottsberg 514/'08, as *M. cerinum* (G); Chile, Schwabe 53 (Herzog); Chiloé Island, Anderson (NY); Chiloé Isl., Cunningham 1445 (NY); Isl. San Pedro, Dusén 535, and without no. (G); Chiloé Isl.; Panguipulli, Padre Hollermayer 279 (YU, Herzog Hb.); same locality, Bro. Claude-Joseph 2322, 2322a (YU); Chiloé Isl., ex Hb. Geheeb, as *M. involutum* (G).—*Straits of Magellan:* Chonos Archipelago, Darwin Bay, without collector, 442 (NY); Gray Harbor, Cunningham 147 (NY); Port Otway, Cunningham 235 (NY); Columbine Bay, West Channel, South Channel, ex Hb. Rome, as *M. cerinum* (NY, G); without locality, Schubert, Hb. Mönkemeyer 8 (G); Tuesday Bay, Naumaun, original of var. *β minimum* (FH); the same, Naumaun 68, 133 p.p. (FH); Desolación Isla, Dusén 143 (2 packets, one as *M. cerinum*) (G).—Patagonia: Haire Molyneux, Husnot 3

(G); Patagonia occ., Isl. Newton, Dusén 76, the original of *M. cerinum* (G); without locality, Hatcher (YU); Patagonia austral., Skottsberg 621 p.p./'08 (G).—Juan Fernandez Islands: several localities, Skottsberg (Swed. Exped. Patagonia, und Feuerl., 1907–1909), including 191, with hyaline underleaves, as *M. skottsbergii* (G); several localities, Skottsberg (Swed. Pacific Exped. 1916–1917), *Bazzania* nos. 7, 10 (S-PA).

33. BAZZANIA SKOTTSBERGII (Steph.) Fulford. Figures 84–90.

Mastigobryum skottsbergii Stephani, K. Svensk Vet.-Akad. Handl. **46**(9): 60. Fig. 22, i, k. 1911.

Mastibobryum creberrimum Stephani, op. cit. p. 60. Fig. 22, c, d. syn. nov.

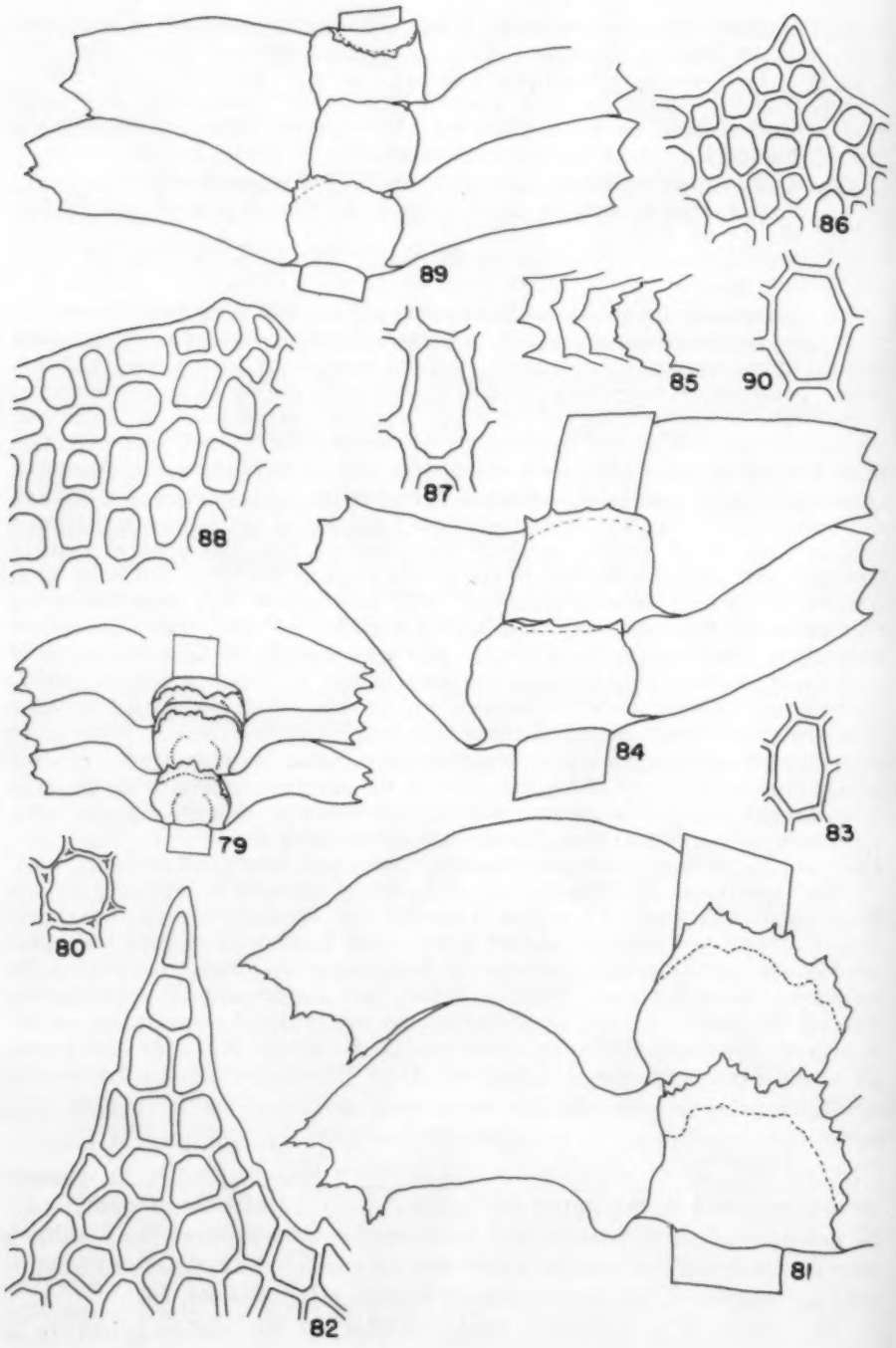
[Stephani, Icones Hep., Mastigobryum no. 156, 115, 445]

Plants medium size to small, in mats, light greenish-brown to dark brown: stems mostly 3 cm, rarely to 5 cm long, with leaves mostly 2 mm broad, prostrate to ascending; lateral branches diverging at an acute angle; flagelliform branches frequent; rhizoids frequent, on the bases of the underleaves and leaflets of the flagelliform branches; the line of leaf insertion little curved in the upper part, the leaves imbricated, plane, unsymmetrically ovate, to 1.5 mm long, to 0.8 mm broad at the base, narrowed a little to the transversely truncate, tridentate apex; the dorsal margin arched from a curved base which covers one-half the stem or less, the ventral margin straight, both margins serrate in the apical region; the teeth 2–4 cells long, slender to spinose or obscure; leaf cells thin-walled but soon becoming thickened, the trigones small, the lumina angular-rounded, the cuticle often strongly verruculose; cells of the apical region mostly 24–27 μ or more $\times$ 24 μ, those of the median and basal portions larger, a vitta not differentiated; underleaves approximate to imbricated, broader than long and broader than the stem, rarely recurved above, the margin rarely incised, more often with distant short spines, or only serrate, or entire, with scattered hyaline cells, or one or two rows of hyaline cells on the margin; leaflets of the flagelliform branches scale-like, ovate: sexual branches and sporophytes not seen.
Lectotype: Juan Fernandez, Masatierra, Skottsberg no. 50 (G).
Habitat: In tufts or mats on rocks and bases and trunks of trees.

The specimen, Skottsberg no. 621, from Patagonia austral, in the Stephani Herbarium (G), which is labeled "*M. skottsbergii* Stephani. portion du type" is a mixture of that species and *B. peruviana* with the latter predominating. Since this material is heterogeneous I have designated the collection, Skottsberg no. 50 (G), from Juan Fernandez, Masatierra, the first of the localities cited by Stephani in the original description, as the lectotype. Stephani made his drawings of *M. skottsbergii* for the Icones Hep., *Mastigobryum* nos. 115 and 445 from plants from Juan Fernandez.

The species is quite distinct when well developed. It is characterized by straight, spreading to ascendant leaves with straight ventral margins (figs. 84, 89); short teeth on the leaves which may be faintly to strongly serrate or entire in the upper part (figs. 84, 85); leaf cells predominantly 27 μ long and thick-walled; and underleaves broader than long, with a serrate, rarely incised margin which may or may not have scattered hyaline cells or a border of one or two rows of hyaline cells (figs. 84, 89).

The species *M. creberrimum* Stephani (figs. 89, 90), differs primarily in


89
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82

that most of the cells are 24 μ, thin-walled, with the trigones inconspicuous. Although Figure 22c, of the original description shows an undivided leaf, most of the leaves on stems of the original collection are shortly three-toothed. The material, which was fragmentary and poorly developed, appears to have grown in a poor but sheltered habitat.

Distribution: Chile: Corral, Thaxter 68 (MICH); Valdivia, without collector (G); Chiloé Isl., San Pedro, Skottsberg, as *M. creberrimum* (G).—Straits of Magellan: Smyth Channel, without collector, ex Hb. Bescherelle, as *M. involutum* f. *minor* (G).—Patagonia: Pat. austral, Skottsberg 621 p.p. /'08 (G); Pat. occid., Skottsberg 876, original of *M. creberrimum* (G).—Juan Fernandez Islands: Masatierra, Skottsberg 50, the lectotype, and 118 (Swed. Exped. Pat. und. Feuerland, 1907–1909) (G); Masatierra, Skottsberg *Bazzania* nos. 1, 2, 3, 4, 6, 7, p.p. 8, 9, 11, 12, 13, 14 (S-PA).

34. BAZZANIA NOVAE-ZEALANDIAE (Mitt.) Besch. & Massal.

Specimens have been reported from the southern tip of South America but none has been seen during the course of the studies.

STUDIES ON AMERICAN HEPATICAE.
10. A SUPPLEMENT TO "THE GENUS BAZZANIA IN CENTRAL AND SOUTH AMERICA."
II. TRIDENTATAE (4)

SECTION 4. APPENDICULATAE

Plants with leaves sharply three-toothed, obscurely three-toothed, subentire or undivided, attached in an oblique line ending in a hook on the dorsal side of the stem; the ventral bases dilated to a greater or lesser degree to form entire, serrulate, dentate, incised or appendiculate auricles; the underleaves large, cordate, more or less auricled, attached in a recurved line.

KEY TO THE SPECIES

Plants with the leaf apices broad, rounded-entire, subentire or with three short, broad lobes or teeth; the leaves spreading.
Leaves rounded-entire, the trigones large, knot-like ..... 42a. *B. placophylla*
Leaves subentire or with three low, broad teeth; the cell-walls thin, the trigones smaller ..... 42. *B. canelensis*

FIGS. 79–83. *B. peruviana*. FIG. 79. Portion of a plant, ventral view, × 15. FIG. 80. A cell from the apical portion of a leaf, × 350. FIG. 81. Portion of a stem, ventral view, × 38. FIG. 82. A tooth of a leaf, × 350. FIG. 83. A cell from the apical portion of a leaf, × 360. FIGS. 84–90. *B. skottsbergii*. FIG. 84. Portion of a plant, ventral view, × 38. FIG. 85. Apices of leaves, × 38. FIG. 86. A portion of the apical tip of the leaf and a tooth, × 290. FIG. 87. A cell from the apical portion of a leaf, × 360. FIG. 88. Portion of the margin of an underleaf without hyaline cells, × 290. FIG. 89. Portion of a plant, ventral view, × 38. FIG. 90. A cell from the apical portion of a leaf, × 360. Figures 79, 80, drawn from the original material of *B. peruviana* (FH); figures 81–83, from the original collection of *M. cerinum* (G); figures 84–88 from the lectotype of *B. skottsbergii* (G); and figures 89, 90, from the original of *M. creberrimum* (G).

Plants with the leaf apices conspicuously three-toothed.
Ventral auricles of the leaves and the margins and auricles of the underleaves undulate and serrate to dentate; the cuticle rough ..... 35a. *B. schlimiana*
Ventral auricles of the leaves and the auricles of the underleaves not as above.
Plants very large, the leaves falcate; underleaves with one or more very long sharp teeth at a right angle to the lateral margin ..... 41. *B. acanthostipa*
Plants medium size to large or robust; underleaves with short marginal teeth or lobes, or entire or obscurely serrate.
Auricles of the underleaves large, with coarse teeth and/or deeply incised, with several conspicuous appendages, the ventral auricle of the leaf similar.
Plants robust; the underleaves large, the margin obscurely serrate, the appendages of the auricles numerous ..... 42b. *B. macrostipula*
Plants medium size to large; the underleaves variously lobed, toothed or crenulate.
Leaves short, narrowed from a very broad base to the obliquely truncate apex; the cells 24–27 μ, the trigones small ..... 38a. *B. boliviana*
Leaves long, becoming falcate; the cells 18 μ, the trigones large, knot-like ..... (some tropical forms of) ..... 36. *B. falcata*
Auricles of the underleaves and ventral base of the leaf variously toothed or lobed or entire, but only rarely with one or more long appendages.
Underleaves (at least some) *deeply* four-lobed or -toothed; the ventral auricles of the leaves more or less conspicuous, with occasional teeth or spines ..... 40. *B. teretiuscula*
Underleaves never deeply four-lobed, the ventral auricles of the leaves large or small.
Underleaves usually large, more or less quadrate, the margin often angled and incised, the auricles more or less toothed; the cells 18 μ, the cavities stellate, trigones very large, knot-like; leaflets of the flagelliform branches large ..... 36. *B. falcata*
Underleaves large, usually entire, the apex undulate or with an occasional tooth; the cell cavities angular-rounded, the trigones large to medium-size.
Leaves not conspicuously narrowed to the apex; ventral appendages rare or absent; the teeth broad, the cells mostly 20 μ, with conspicuous trigones ..... 37. *B. hookeri*
Leaves narrowed to the apex; the teeth sharp, pointed.
Leaves spreading, the cells 18–20 μ; leaflets of the flagelliform branches scale-like ..... 39. *B. liebmanniana*
Leaves more or less falcate; the cells large, 24–36 μ; the leaflets of the flagelliform branches large ..... 38. *B. robusta*

35. BAZZANIA ASPERISTIPULA (Steph.) Fulford = *Bazzania schlimiana* (G).

35a. **Bazzania schlimiana** (Gottsche) Fulford, comb. n.
Mastigobryum schlimianum Gottsche, Ann. Sci. Nat. V. **1**: 140. 1864.
Mastigobryum asperistipulum Stephani, Spec. Hep. **6**: 453. 1924. syn. nov.
Bazzania asperistipula (Steph.) Fulford, *Bazzania*, p. 125. 1946. syn. nov.
[Stephani, Icones Hep., *Mastigobryum*, no. 398a]

The species *M. asperistipulum* from Guatemala is identical with *M. schlimianum* Gottsche from Colombia and thus goes into synonomy under the older name.

Habitat: In deep tufts on stumps, logs and tree trunks.

Distribution: Guatemala: Alta Verapaz, Cobán, 1600 m., Türckheim (Hb. Levier 5817), the original of *M. asperistipulum* (NY, G); the same, 5503 as *M. teretiusculum*, 5582 (NY); without locality, Seler 2659, as *M. braunianum* (G); El Progresas, Sharp 2736a (TENN).—Costa Rica: Coliblanco, 1950 m., Maxon 237 (NY); Vara Blanca, 1600–1700 m., Maxon & Harvey 8266 (Hb. Herzog); Santa Clara de Cartago, 1950 m., Maxon & Harvey 8188 (Herzog); Cerro de la Carpintera, Standley 35632 (US); Orosi, Standley 39650 (US); Alto de la Estrella, Standley 39106, 39403 (US); El Muñeco, Standley 51338 (US); Prov. Heredia, 2000–2400 m., Standley 52164a (Hb. Herzog).—Colombia: without locality, Wallace (NY); Merida, Moritz, as *M. arcuatum* (G); Merida, Moritz 167 (G); Merida, Funck & Schlim 167, as *M. portoricense* (G); Prov. Rio Hoche, Sierra Nevada, 10,000′, Schlim 868, the original (G); Dept. Norte del Santander, Cuatrecasas, Schultes & Smith 12448GG, 12448K, 12448M, 12448W (US); Dept. del Valle, Monte La Guarida, Cuatrecasas 22196 (US).—Venezuela: Caracas, without collector (FH); the same, without collector, HB Gottsche (ex hb. Jack) 1002, 1003 (G).—Brazil: Rio de Janeiro, Schiffner 623 (W); Apiahy, Puiggari (296 (?) (G).—Ecuador: Quito, Cuming as *M. humifusum* (G); Paraná del Matauga, 3400 m., Allioni 681, as *M. arcuatum*.—Peru: Callao, Nöllner (G).

36. BAZZANIA FALCATA (Lindenb.) Trevis.

Some of the collections from Costa Rica and northern South America have stems in which the margins of the underleaves are more incised and toothed and the auricles more abundantly appendiculate than was described for *B. ancistrodes* which was reduced to synonomy under *B. falcata* in the earlier study. The occurrence of teeth and appendages appears to be a variable condition and there is a range from no or rare appendages in the appendages in the *M. falcatum* of the West Indies to several to numerous appendages in *B. ancistrides* and other South American collections, but there are no clear cut characters on which to keep them distinct. Even the appendiculate forms may be readily separated from the other species with appendages since in *B. falcata* the cells are mostly 18 μ, with large, knot-like trigones and stellate cell cavities, while in the other species the cells are mostly 24 μ or larger and the cell lumina are only angular-rounded and the trigones are not so large.

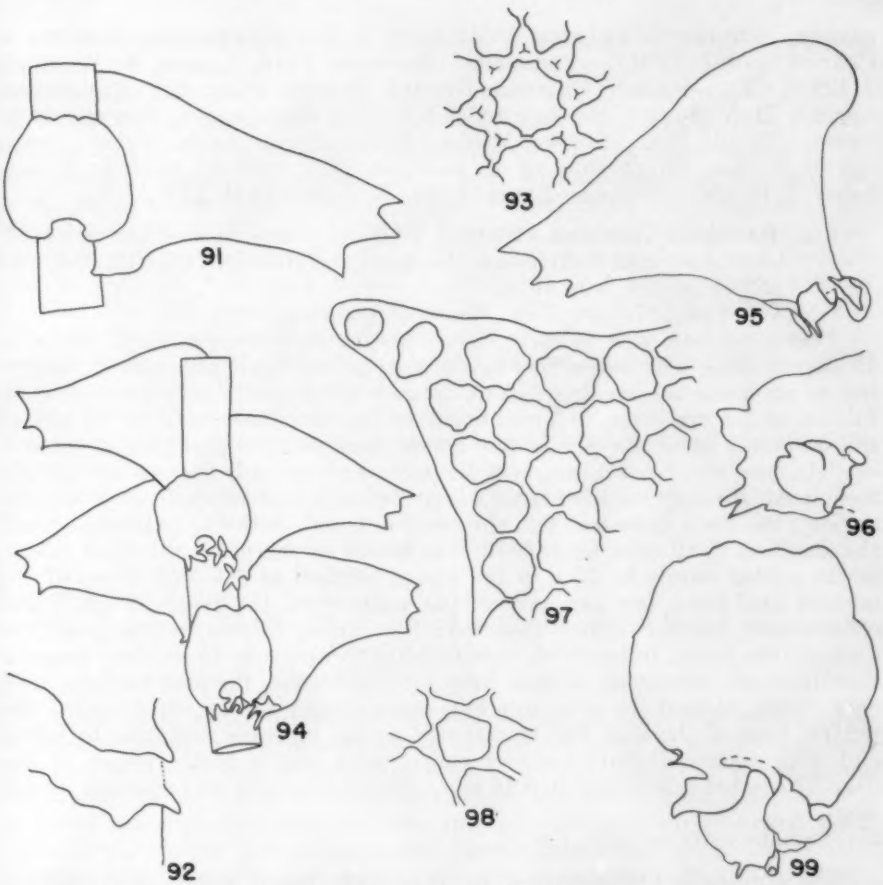
Habitat: In tufts or scattered among mosses on logs and rocks, rarely on leaves in forests.
Distribution: Cuba.—Jamaica.—Puerto Rico.—Guadeloupe: (original, NY, (G); add, without locality, l,Herminier 159, Hb. Gottsche 1007 (G); St. Vincent.—Trinidad: add, Tucuche, Broadway 7100 (BM).—Costa Rica: Los Angeles de San Ramón Brenes 17117 (F); Peralta, Alfaro 40, 48a (F). —Colombia: Dept. del Valle, Puerto Merizalda, Cuatrecasas 14049b (US); Rio Calima, Cuatrecasas 21179b (US).—Venezuela: Cumbre, Maguire, Cowan & Wurdack 30697 (NY).—Brazil: add, Sta. Catarina, Carl 145 (Hb. Herzog); S. Paulo: Campo Grande, Schiffner 464, 465 (W).—Ecuador: add, Qualaquiza, Allioni 526, as *M. arcuatum* (G); without locality, Allioni, (Hb. Levier 6578 p.p.), as *B. ecuadorensis* (G);—Peru.—Bolivia, Mapari, 5000′, Rusby 3027, as *B. arcuata* (G).

37. BAZZANIA HOOKERI (Lindenb.) Trevis.

Habitat: On soil and on bases and trunks of trees.
Distribution: Cuba.—Jamaica: add, John Crow Peak, Philipson 1083 (BM); s.e. slope of Mossman's Peak, M. Farr 730 (IJ). Santo Domingo: Quita Espulla, Abbott 2137 p.p. (BM).—Guadeloupe: (original G, NY); add, without locality, l'Herminier 53c, 59, 140 and several without numbers (G); without locality, l'Herminier 121, 114 as *M. portoricense* (G); without locality, l'Herminier, Hb. Gottsche 1001 (G); forêt de Baines Jaunes, Le Gallo 245, 260 p.p., 262 p.p. (Le Gallo); Galion, Le Gallo 255 (Le Gallo).—Dominica: without locality, Elliott 1014 p.p. 1167 as *M. arcuatum*, 1932 as *M. portoricense* (G).—Trinidad: add, Tucuche, Broadway 7098 (BM).—Guatemala: Nebáj. 8500′, Sharp 2516 (TENN); Pitoreal, Sharp 2771a (TENN).—Costa Rica: Los Angeles de San Ramón, Brenes 16264, 17121, 19018 (F); Sarchi, Alfaro 7 (F).
Colombia: Rio Papuri, Teresita, Schultes & Cabrera 19457 (FH); Rio Hacho, Sierra Nevada, 10,000′, Schlim 868, as *M. stolonifera* (G); Dept. Norte de Santander, Sarari, Cuatrecasas, Schultes & Smith, 12448aa, B, J, U (US).—Venezuela: Estadó Bolivar, Tirepon-tepui, Wurdack 34057 (NY); Caraças, Fendler (G); Caraças, Al. Braun 1215, the original of *M. braunianum* (G) the same, 1213 (G); Estado Bolivar, Chimanta Massif, Steyermark 74966, 75217 (US).—Brazil: add, Petropolis, Döring (G); Parana, Dusén 3869 as *M. portoricense* (G); Sta. Catarina, Carl 145 (Hb. Herzog); Apiahy, Puiggari 296 III, as *M. portoricense* (G); Minas Gerais: Caraça, Wainio 12, as *M. arcuatum* (G).—Ecuador: add, Manabi, Wallis, as *M. arcuatum* (G).—Peru: add, without locality, Weddell, the original of *M. superbum* (G).—Bolivia: add, Tablas, 1800 m., Herzog 4620, the original of *M. douini* (G); Tocorani, 3000 m., Herzog 3841a (G); Yungas, 6000′, Rusby 2029, as *M. portoricense* (G); N. Yungas, 1300 m., Buchtian 17202 (Hb. Herzog).

38. BAZZANIA ROBUSTA Spruce. Figures 91–93.
add syn. *Mastigobryum javitense* Stephani, Spec. Hep. **3**: 528. 1909.
syn. nov. [Stephani, Icones Hep., *Mastigobryum* no. 389]

The species *M. bolivianum* Stephani, was erroneously placed in synonomy under this species, it is described under no. 38a. The distinguishing characters of the species are its medium to large size and deep yellow brown color; the spreading-arcuate leaves with three sharp teeth usually ending



FIGS. 91–93. *B. robusta.* FIG. 91. Portion of a plant, ventral view, × 15. FIG. 92. The ventral base of underleaves, × 30. FIG. 93. A cell from the apical portion of a leaf, × 350. FIGS. 94–99. *Bazzania boliviana.* FIG. 94. Portion of a plant, ventral view, × 15. FIG. 95. A leaf, × 25. FIG. 96. The ventral base of a leaf, × 40. FIG. 97. A tooth of a leaf, × 360. FIG. 98. A cell from the apical portion of a leaf, × 360. FIG. 99. An underleaf, showing the appendaged auricles at the base, × 33. Figures 91–93 drawn from the original of *M. javitense* (G); and figures 94–99 drawn from a portion of the original of *M. bolivianum* (G).

in two-celled tips; the large cells, 32–36 μ long, with very large, knot-like trigones; and the large, rounded, cordate-auriculate underleaves. There are no appendages on the expanded ventral auricles of the leaves or on the underleaves.

Habitat: In deep ascending tufts, on decaying logs and rocks and on trunks and branches of trees in humid forests.

Distribution: Colombia: Rio Apoporis, Schultes & Cabrera 12345, 15354 (FH); Rio Kananari, Schultes & Cabrera. 13200a p.p. (FH); Rio Miriti-

parana, Schultes & Cabrera 16552 (FH); Rio Piraparana, Schultes & Cabrera 17097 (FH).—Venezuela: Serrania Parú, Cowan & Wurdack 31429 (NY).—British Guiana.—Brazil: Panuré along the Rio Negro, Spruce, Hep. Spruc., the original (NY, G); Rio Uaupes, Spruce, Hep. Spruc. [B 20] (G); Santos, Mosén (FH).—Peru: Andes Peruv., sylva Javitá, Spruce, the original of *M. javitense* (G); without locality, Weberbauer 1248 (G).—Bolivia: Santa Anna, Williams 2161 (YU, NY).

38a. **Bazzania boliviana** (Steph.) Fulford, comb. nov. Figures 94–99. *Mastigobryum bolivianum* Stephani, in Herzog, Biblioth. Bot. **87**: 223. Fig. 164, f–h. 1916.

[Stephani, Icones Hep., *Mastigobryum* no. 308]

Plants medium size to large, in yellow to dark brown mats; stems to 12 cm (?) long, with leaves to 3 mm broad; lateral branches distant, diverging at an acute angle; flagelliform branches frequent: leaves imbricated, falcate, to 2.3 mm long, to 2 mm broad at the base, narrowed to 0.8 mm at the obliquely truncate apex; the dorsal margin strongly arched from a cordate base which extends across the stem and beyond, the ventral margin ascendant, strongly concave from a large, incised and appendiculate ventral auricle; the apex three-toothed, the teeth unequal, with the basiscopic tooth the smallest, 6–10 cells long, 6–10 cells broad as the base; the cells mostly 22–24 μ long, rarely to 27 μ in the apical portion of the leaf, those of the median and basal portions larger, the walls thin, the trigones small and conspicuous, the cell lumen rounded; the cuticle faintly verruculose; the underleaves large, imbricated, subquadrate to elongate in outline, broader than the stem, averaging 12 mm. long, 0.9 mm. broad, the base cordate, with very large, incised auricles and long appendages similar to those of the ventral base of the leaf, the lateral and apical margins undulate to lobed, and with scattered short teeth or rarely with longer teeth: leaves of the flagelliform branches long, to 0.24 mm.: sexual branches and sporophyte not seen.

Habitat: In mats on logs.

The species is characterized by the short, broad leaves, and the appendiculate, incised auricles of the ventral base of the leaf and the auricles of the underleaf (figs. 94–96, 99). This latter character together with the smaller leaf cells, mostly 22–24 μ long, will at once separate this species from *B. robusta*, which has leaf cells 30–36 μ long and has no appendages on the auricles of the leaves or underleaves. It can be separated from the forms of *B. falcata* which bear appendages, by the cell size, since the cells of the latter species are only about 18 μ, with very large, knot-like trigones and stellate cell cavities.

Distribution: Colombia: Santander, H. Bischler 83 (Bischler); San Cristobal, Bogotá, LaCouture 33, as *M. humifusum* (G).—Venezuela: Estrado Bolivar, Chimantá Massif, Steyermark, 75130, 75131 (NY).—Brazil: Rio Uaupes, Spruce [B 34], as *B. spinigera*, Hep. Spruc. (G.)—Eucador: Gualaquiza, Allioni, Hb. Levier 6402, 6403 (G).—Peru: Junin, 2700 m, Weberbauer 2304, as *B. ancistrodes* (G); Chimborazo, Spruce, Hep. Spruc., as *B. ancistrodes* (G). Bolivia: Corani, 2600 m., Herzog 5072, the original (G).

39. BAZZANIA LIEBMANNIANA (Lindenb. & Gottsche) Trevis.
Habitat: Not given.
Distribution: Mexico: (original, FH, G, very poor).—Guatemala.

40. BAZZANIA TERETIUSCULA (Lindenb. & Gottsche) Trevis.
Habitat: On rocks and bases of trees on shaded slopes in moist forests.
Distribution: Mexico: (original, G); add, without locality, Karsten 94, as *M. portoricense* (G); without locality, Sumichrast (G); Chiapas: n'r Mapastepec, Sharp 4558 p.p. (TENN.)—Costa Rica.—Columbia: add, Cor. dillera Macarena, Schultes & Bell 11655 (FH).—Venezuela: Cerro Huachamacare, Maguire, Cowan & Wurdack 30270 (NY).—Brazil: add, without locality, Ule 140, as *M. portoricense* (G); Rio de Janeiro, Schiffner 836 (W); S. Paulo: n'r Itapecica, Schiffner 1264 p.p. (W); S. Paulo: Alto de Serra, Schiffner, 1706 (W); S. Paulo: n'r Santos, Schiffner 1939 p.p., 1953 (W).—Ecuador.—Peru.—Bolivia.

41. BAZZANIA ACANTHOSTIPA Spruce.
Habitat: In deep ascending tufts, on rocks and trees in moist places in the mountains.
Distribution: Colombia: add, Rio Apoporis, Schultes & Cabrera 11958 (FH).—Peru: (original, NY, G).—Bolivia.

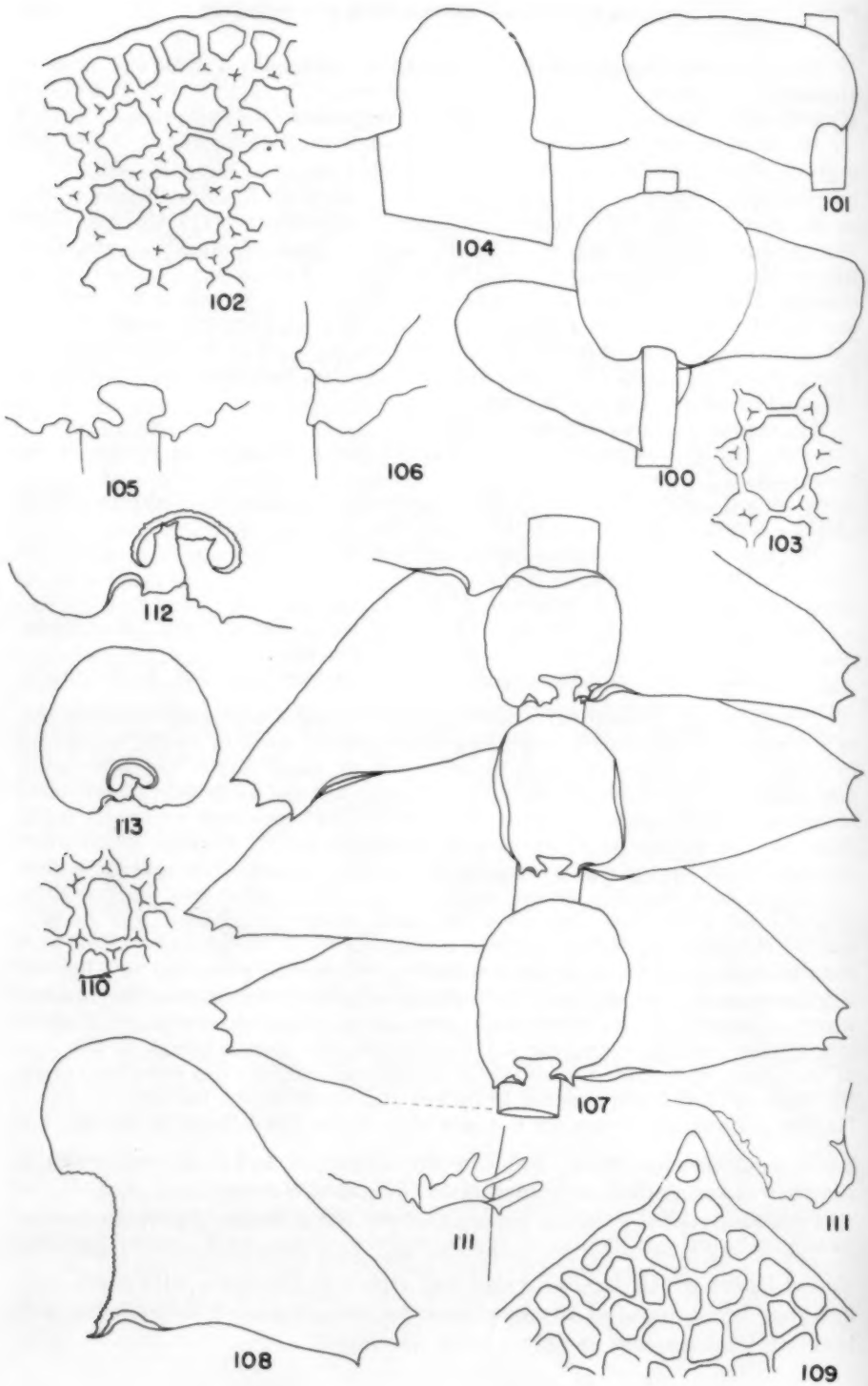
42. BAZZANIA CANELENSIS (Steph.) Fulford.
Habitat: On tree trunks in forests.
Distribution: Ecuador: (original, FH, NY, G).

42a. BAZZANIA PLACOPHYLLA (Tayl.) Grolle, Rev. Bryol. et Lichén. **27**(½): 54. f. 1–5. 1958. Figures 100–106.
Jungermannia placophylla Taylor, London Jour. Bot. **5**: 276, 1846.

Plants large, in deep tufts, olive green becoming brownish: stems large, to 10 cm or more in length, with leaves to 3 mm or more in width, ascending to erect; lateral branches rare, diverging at an acute angle, the subtending leaf similar to the leaves in shape and length but not so broad; flagelliform branches and rhizoids not seen: the line of leaf-insertion recurved hook-form in the upper part; the leaves approximate to slightly imbricated, oblong, plane, spreading, averaging 1.5 mm in length, 0.96 mm in width, the dorsal base strongly arched and cordate, the ventral base only a little dilated and auriculate, the apex rounded, broad, undivided, the margin entire; the cells appearing in rows, averaging 18 μ, the trigones large with rounded sides, coalesced or separated by thin-walled pits; the cell lumina angular-rounded to stellate, the cuticle roughly verruculose: the underleaves approximate to imbricated, very large, round-quadrate, to slightly longer than broad, averaging 1.1 mm across, the base straight to the line of insertion, or rounded, or slightly cordate-auriculate, the margins entire, the cells as in the leaf: sexual branches and sporophytes not seen.
Habitat: Mountain slopes on the east side of the Cordilleras of Peru.

This species has been "lost" in the literature and it is only recently that it was recognized as belonging to the genus *Bazzania*.

It is easily distinguished from all of the other South American species of this genus because of its large size and pale brownish-green color; the oblong leaves which are undivided and entire at the apex, with small cells and very large, rounded trigones; and the large, rounded underleaves with basal auricles scarcely or only a little developed.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The species is similar in general habit to *B. canelensis* but they differ in that the leaves of *B. canelensis* have large, undulate ventral auricles, faintly three-toothed or -lobed apices and well developed auricles on the underleaves. *B. placophylla* is more closely related to *B. canelensis* than to any other species of the Appendiculatae.

Distribution: Ecuador: Quito, Jameson 122 (BM); Peru: "East declivity of the Cordilleras of Peru," Jameson, the original, cited by Grolle (W, S-PA).

42b. **Bazzania macrostipula** Fulford, n. sp. Figures 107–112.

Caules robusti, olivacei-virides vel flavofusculi foliis patientibus, longis, basi 2 mm latis, versus apicem tridentatum diminuendis ad 0.5 mm in latitudinem, marginibus serrulatis vel serratis, dentibus grandibus apice 2-cellulatis; foliae cellulae 16–18 μ parietibus incrassatis, trigonibus parvis: amphigastria 1 mm longa, 1.5 mm basi lata, cordata auriculis grandibus, undulatis appendiculatis marginibus obscura serratis.

Plants large, olive green becoming yellowish brown in the older portions: stems large, to 10 cm or more in length, 5–6 mm broad; lateral branches rare, diverging at an acute angle; flagelliform branches and rhizoids not seen: the line of leaf insertion recurved hook-form at the dorsal end; leaves imbricated in the basal third, spreading, often becoming slightly falcate near the tip, tending to be symmetrical, ovate to 3.5 mm long to 2 mm broad at the base, narrowed to 0.5 mm at the truncate, usually tridentate apex; the dorsal margin strongly arched from a cordate base, with occasional serrulations, the ventral base dilated, often recurved, bearing several teeth or long appendages, the ventral margin straight, undulate, distantly serrulate to serrate; the apex narrow, three-toothed, the teeth equal or with the basiscopic tooth smaller, mostly 10–12 cells long and broad at the base, the tip a spine of 1–2 cells, the sinuses broad, lunulate, the margins more or less serrate; leaf cells thin-walled, the cell lumina rounded, the trigones small, the cuticle smooth to faintly verruculose; cells of the apical region and dorsal base small, 16–18 μ, quite uniform, those of the interior and base larger: the underleaves approximate, broadly oval, averaging 1 mm long, 1.5 mm broad at the line of attachment, the base strongly cordate, the auricles large, approximate, undulate, with several short or long, tooth-like appendages, or rarely incised, the lateral margins undulate, the apical margin rounded, both obscurely serrate: male branches short; female branches and sporophytes not seen.

FIGS. 100–106. *B. placophylla*. FIG. 100. Portion of a stem, ventral view, × 15. FIG. 101. A stem and leaf, dorsal view, × 15. FIG. 102. Portion of the apical margin of a leaf, × 350. FIG. 103. A cell from the apical portion of a leaf, × 360. FIG. 104. The insertion of an underleaf on the stem, × 65. FIG. 105. Another, × 40. FIG. 106. Ventral auricles of leaves, × 40. FIGS. 107–113. *B. macrostipula*. FIG. 107. Portion of a plant, ventral view, × 15. FIG. 108. A leaf, × 15. FIG. 109. A tooth of a leaf, × 360. FIG. 110. A cell from the apical portion of a leaf, × 360. FIG. 111. Ventral auricles of leaves, × 50. FIG. 112. Basal part of an underleaf to show the expanded auricles, × 40. FIG. 113. An underleaf, × 15. Figures 100–106 drawn from a portion of the material collected by Jameson in Ecuador (BM); and figures 107–113 from a portion of the original material (BM).

Habitat: Not given.

The species *B. canelensis, B. placophylla* and the new species are quite similar in general aspect, greenish-brown color and robust size. They are found in the same general region of South America. However, each is quite distinct and easily recognizable. In *B. canelensis* the leaves are broad and retuse or have two or three broad teeth or lobes at the apex and the ventral auricles of the leaves and the auricles of the underleaves are undulate and not toothed or appendiculate. In *B. placophylla* the leaves are broad, rounded and entire at the apex, the trigones are large, and the ventral base is only a little dilated and scarcely auriculate. The underleaves may be cordate but are, for the most part, without basal auricles. In *B. macrostipula* the leaves are conspicuously narrowed and three-toothed at the apex, and the ventral auricles are dilated, toothed, appendiculate or incised, as are the auricles of the underleaves.

Distribution: Ecuador: without locality, Fraser 1, the original (BM); without locality, Fraser (HB. Levier 1228), as *M. superbum* (G).

STUDIES ON AMERICAN HEPATICAE.
11. A SUPPLEMENT TO "THE GENUS BAZZANIA IN CENTRAL AND SOUTH AMERICA."
II. TRIDENTATAE (5)

SECTION 5. VITTATAE

Plants with three-toothed leaves in which a vitta of several rows of elongate, thin-walled cells with large trigones is conspicuously developed. Although the Section forms a clearly distinct unit within the genus, some of the species are not so clearly delimited. It would seem that the group as a whole is an ancient one because of the generally Antarctic distribution of most of the species.

KEY TO THE SPECIES

Plants with underleaves chlorophyllose throughout, subquadrate to ovate in outline, the lateral and apical margins variously lobed, toothed and incised ..... 43. *B. spruceana*

Plants with underleaves hyaline at least in the upper part, more or less regularly four-toothed, the lateral margins undivided, entire.

Cuticle of the leaves and underleaves abundantly minutely punctate; teeth of the leaves well developed, 4–6 cells long; the underleaves hyaline throughout, often two-four lobed above ..... 44. *B. tayloriana*

Cuticle of the leaves and underleaves smooth to verruculose; teeth of the leaves one or two cells long, often recurved, sometimes absent; underleaves chlorophyllose in the lower part.

Underleaves distant, one-third to one-half divided into four slender, acute, often spreading teeth ..... 45. *B. convexa*

Underleaves often approximate to imbricated, broader than the stem, undivided, emarginate or with two to four obtuse lobes or teeth (some underleaves of a stem may have four acute teeth ..... 46. *B. heterostipa*

43. BAZZANIA SPRUCEANA Stephani.
add syn. *Mastigobryum burchelii* Stephani, Spec. Hep. **3**: 509. 1908 syn. nov.
[Stephani, Icones Hep., *Mastigobryum* no. 340]
Habitat: Not given.
Distribution: Peru: (original, FH, G).—Brazil: Burchell 3847 p.p., original of *M. Burchellii*, "with *M. richardianum*, Fretum Magellanicum" (G), which is an incorrect label for this collection which is identical with Burchell 3847, "Pl. Brasil trop", which contains both *M. burchellii* Stephani and *M. heterostipum* Stephani, (NY).

44. BAZZANIA TAYLORIANA (Mitt.) Fulford.
Habitat: On soil among other bryophytes.
Distribution: Colombia.—Africa.—New Zealand (original, NY, G).—Samoa (Stephani).

45. BAZZANIA CONVEXA (Thunb.) Trevis.
Mastigobryum richardianum Mitten, in Hooker, Bot. Ant. Voy. **2**^{2}(Fl. N. Zel.): 147. 1854.
[delete synonym—*M. heterostipum* Stephani, in error!]

This species and the next, *B. heterostipa* (Steph.) are quite similar in a number of their characters and form a complex with a high degree of variation in the leaves and the underleaves. While the two are distinct, there seem to be integrading forms which could belong to either species. In addition to this there has been a confusion of labels on some of Stephani's packets.

The first American member of this complex to be recognized was *M. richardianum*, collected by Richard from Magellan Straits and described by Mitten in 1854. These plants have leaves with recurved teeth one or two cells in length and underleaves which are hyaline nearly to the base. They are divided to one-third or one-half into four, erect spreading, slender teeth. These teeth are two cells broad for most of their length. This taxon, with apparently less variability, was recognized earlier from the Cape of Good Hope by Thunberg in 1794 as *Jungermannia convexa*, so that the American species was reduced to synonomy under *B. convexa* (Thunb.) Trevis. The confusion concerning *M. richardianum* in South America came about when Stephani (Spec. Hep. **3**: 532. 1908) described and illustrated (Icones, Hep., *Mastigobryum* no. 444), plants from a packet, now at Geneva, labeled "*M. Richardianum* cum *Mast. Burchellii* St. Hb. Burchell 3847. Herb. Kew. Fretum Magellan. Portion du type." The plants were not a portion of the original of *M. richardianum* which was collected by Richard. They are a portion of a collection made by Burchell in Brazil, part of which is in the Herbarium of the N. Y. Botanical Garden and labeled, "Burchell, Cat. Geogr. Pl. Brazil Trop. no. 3847." These plants belong to *B. heterostipa* (Steph.) and will be discussed under that species. Mixed with these plants are stems of *M. burchellii* which has already been reduced to synonomy

under *B. spruceana*, No. 43. There seems to be no part of the original collection of *M. richardianum* in the Stephani Herbarium.

Habitat: In mats on soil and among rocks or mixed with other bryophytes. Distribution: Brazil: add, S. Paulo: Barra Mansa, Schiffner 536, 577, 1801, 1817, 1850 (W); S. Paulo: Brasso Grande, Schiffner 1429, 1430 (W); S. Paulo: n'r Santos, Schiffner 1956 (W).—Chile: Chiloé Island, Capt. King (NY).—Patagonia: Albert Bay, Dr. Coppinger (NY); Straits of Magellan: Richard, the original of *M. Richardianum* (NY).—Central Africa.—South Africa—Australia.

46. **Bazzania heterostipa** (Steph.) Fulford comb. n.
Mastigobryum heterostipum Stephani, Spec. Hep. **3**: 532. 1909.
add syn. *Bazzania stephani* Fulford, *Bazzania*, p. 162, f. 59. Non *Mastigobyrum stephani* Jack, *in* Stephani, Hedw. **25**: 235. pl. 1, f. 1012. 1886.

Another segment of the complex to which *B. convexa* belongs, was described by Stephani as *M. heterostipum* from "America tropica et subtropica, haud rara." Although Stephani did not designate a particular locality in the citation of the specimens, he illustrated (Icones Hep., *Mastigobryum* no. 443), leaves and underleaves of plants from Brazil, collected by Ule, Puiggari (Apiahy), and Didrichsen (Petropolis). Since during the preparation of the earlier monograph only material collected by Ule was available (Stephani collection at Farlow Herbarium) it was designated as the type. These stems are highly variable, some branches have some of the underleaves more or less divided to one-third into four acute teeth like the underleaves of *B. convexa*, while many more have the underleaves longer and broader than the stem and either undivided or with two to four lobes. The leaf apices vary from rounded-entire to scarcely toothed, to three distinct one- or two-celled recurved teeth. Because parts of the stem were similar to *B. convexa* I reduced the species to synonomy under that species. Now that much additional material from the collections made by Schiffner in Brazil has been studied, it is evident that *M. heterostipum* is a distinct but variable entity as is *B. convexa*. The collections of Ule, Puiggari and Didrichsen, from Brazil mentioned above represent *B. heterostipa* rather than *B. convexa* and the lectotype is the collection by Ule, no. 168.

The plants of the collection by Burchell, no. 3847, Cat. Geogr. Pl. Brazil trop. from the Herbarium of the N. Y. Botanical Garden which were assigned by me (1946, p. 162, f. 59) to *B. stephani* also belong to *B. heterostipa*. In all probability *M. stephani* Jack, from Africa and *B. heterostipa* are one species, but since only one short stem of the African species was available, it would seem that at least for the present the two should be recognized as separate species until *M. stephani* is better known.

Habitat: In tufts over rocks and soil or with other bryophytes.
Distribution: Brazil: Blumenau, Ule 168, the lectotype (FH, G); without locality, Ule 40 (G); Petropolis, Didrechson (G); Apiahy, Puiggari 766b (G); without locality, Burchell 3847 p.p., Cat. Geogr. Pl. Brazil trop. (with *M. burchellii*) (NY); part of the same, incorrectly labeled as *M. richardianum* "Fretum Magellan, no. 3847, ex Hb. Burchell, ex Hb. Kew, Portion du Type" (G); S. Paulo: n'r Santos, Schiffner 105, 1939 (W); S. Paulo: Alto da Serra, Schiffner 181, 1690 (W); S. Paulo: Barra Mansa, Schiffner 495, 1817, 1874 (W); S. Paulo: Rio Grande, Schiffner 707 (W); S. Paulo: Itapecirica, Schiffner 1264 (W); S. Paulo: Brasso Grande, Schiffner 1294, 1309, 1429, 1549, 1557 (W).

Two of the species in this Vittatae Section have a distinct Antarctic distribution and it is highly probable that *B. heterostipa* will fall into this same group when *M. stephani* from Johanna Island (Cormoro Group) is better known.

Although the previous list of species "not available for study" has been reduced considerably, several names still remain for which no type or original collection has been found as yet. Several species which were first described from other areas and later reported from America are also included, since the American specimens on which the reports were based have not been studied. The following names belong in these groups:

Bazzania adnexa (L. et L.) Trevis., reported from Chile by Herzog. Arch. Exc. Farm. Cien. Méd. Córdoba 1938. No. 7. p. 26. 1938.
Bazzania bidens var. *heterodonta* Spruce, Trans. & Proc. Bot. Soc. Edinb. **15**: 372. 1885. Peru.
Mastigobryum brasiliense Gottsche & Lindenberg, in G. L. & N., Syn. Hep. 227. 1845. Brazil.
Mastigobryum breutelianum var. *guadeloupense* Bescherelle, Jour. Bot. **7**: 187. 1893. Guadeloupe. (nomen nudum).
Mastigobryum decurrens Stephani, Bibliotheca Bot. **87**[2]: 223. 1916. Bolivia.
Mastigobryum fuegianum Sullivant, Jour. Bot. [Hooker] **2**: 317. 1850. Tierra del Fuego.
Bazzania humifusa var. *olivacea* Spruce, Trans. Proc. Bot. Soc. Edinb. **15**: 380. 1885. Peru.
Mastigobryum portoricense var. *laxa* Bescherelle, Jour. Bot. **7**: 186. 1893. Guadeloupe. (Nomen nudum).
Herpetium scutigerum Montagne, Ann. Sci. Nat. II, Bot. **9**: 44. 1838. Peru.
Mastigobryum venezuelanum Molkb. ms. in Sande Lacoste, Sny. Hep. Javan. 104. 1857. Venezuela.
Bazzania vincentina var. *macrophylla* Spruce, Trans. Proc. Bot. Soc. Edinb. **15**: 378. 1885. Ecuador.
Mastigobryum platycnemum Schwägr. n. sp. in Hb. Gottsche, in Stephani, Spec. Hep. **3**: 460. 1908. "Insulae Marianae" reported from Falkland Islands by Stephani, Icones Hep., *Mastigobryum* no. 148.

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Gottsche, C. M. 1863. De Mexikanske Levermooser. Cõpenhagen.

Herzog, Th. 1938. Hepaticae Standleyanae Costaricenses et Hondurenses. Rev. Bryol. et Lichén. **11**: 5–30. 6 fig.

Lindenberg, J. B. G. & Gottsche, C. M. 1851. Species Hepaticarum. *Mastigobryum*. i–xii, 1–118. 22 pl. Bonn.

Spruce, R. 1884–1885. Hepaticae Amazonicae et Andinae. Trans. Proc. Bot. Soc. Edinb. **15**: i–xi, 1–588. 22 pl.

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————. 1895. Hepaticae Elliottianae, insulis Antillanis St. Vincentii et Dominica a clar. W. R. Elliott, annis 1891–92, lectae Ricardo Spruce determinatae. Jour. Linn. Soc. Bot. **30**: 331–372. 10 pl.

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BULLETIN OF THE TORREY BOTANICAL CLUB

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TORREYA

Skunk Cabbage, Symplocarpus Foetidus

JOHN A. SMALL

This is the time of year when people who enjoy the out of doors begin looking hopefully for spring flowers. One of the most reliable plants to produce such flowers at an early date is the skunk cabbage (*Symplocarpus foetidus*). Pollen was obtained from such a flower in Hutcheson Memorial Forest, East Millstone, N.J., on Jan. 1, 1954. The earliest recorded appearance of an inflorescence at the forest was September 5, 1952. Inflorescences have been seen invariably during January for the many years that the forest has been under observation. There is this early burst then a period when no more flowers appear. The winter's coldest weather is often between late January and early March. Then follows a rapid appearance of flowers and the unfolding of leaves.

Not all plants produce inflorescences in a given season. Any individual plant may

FIG. 1. *S. foetidus* plant lifted March 1955. The numerous large roots are contractile. Note sheathing base of petiole remaining from 1954 leaf; 3 spathes.

have from none to as many as three inflorescences, (Fig. 1) each a spadix of many flowers, enclosed loosely by the familiar mottled spathe. Soon the leaves increase in number and size until the whole area may be a continuous green cover. A plant may produce as many as eight leaves in addition to the two or three green bud scales which first opened. Leaves have been measured with petiole 50 cm. (19.7 inches) and blade 54 cm. (21 inches) long by 37 cm. (14.6 inches) across. Eight of these leaves expanded in all directions from the base will completely cover a lot of ground. By this time, first week of May, the short stalked inflorescences are entirely hidden and most people have

lost interest in skunk cabbage flowers until next winter. But that leaves a lot of questions unanswered. What became of the inflorescences? What percentage of them produced fruit? If a plant had three were they all successful? Do plants in the sun have any advantage or disadvantage over plants growing in the shade? These and other questions prompted the establishment of two plots on the Hutcheson Forest tract. One was in the marsh along Spooky brook near a culvert where the highway crossed the brook. The plants here had full exposure to sunlight all day until the other marsh plants such as *Asclepias incarnata*, several species of *Polygonum*, and sedges overtopped them in late June. By that time the leaves had deteriorated materially. The second plot was upstream in the forest. Even here the plants had a high percentage of available sunlight until the overhead leaf expansion was completed in early May. But the total radiant energy impinging upon the leaves here was much less than in the open marsh.

There were 57 plants on the marsh plot. Twenty-four (42.1%) were sterile in 1959 and thirty-three (57.9%) were fertile–produced inflorescences. A total of 65 inflorescences were produced, averaging 1.97 per fertile plant. Most of these withered or decayed but 9 of them (13.85%) developed into fruits by July 29. Ten plants produced two inflorescences. One of these plants developed 2 fruits but the others were completely unsuccessful. Eleven plants produced three inflorescences. One of these plants developed two fruits, three others developed one fruit each, and seven failed to develop fruit at all.

Within the forest, on a much smaller area, there were 105 plants. Fifty (47.6%) were sterile in 1959 and fifty-five (52.4%) were fertile. A total of 68 inflorescences were produced, averaging 1.24 per fertile plant. Although many of the inflorescences decayed on the forest-grown plants too, there was a markedly greater number of successfully fruiting ones, 26 (39.4%), as of July 24. Nine plants produced 2 inflorescences, three lost both of them subsequently, four produced 1 fruit each, and two succeeded with both fruits. Two plants that produced three inflorescences each were both unsuccessful in producing fruit. In this experiment it can be seen that: 1. plants grew more densely in the forest location, 2. there was slightly more fertility of plants on the marsh, 3. there was a much higher ratio of multiple inflorescences on the marsh and 4. there was a much higher percentages of decaying inflorescences (86.15%) on the marsh as compared with the forest (60.6%). Rosendahl (1911) after studying *Symplocarpus* in Minnesota reported: "In no case have more than two flowering shoots been observed above ground on one plant." He explains that the first flowering shoot to appear comes from the portion of the rhizome "that bore the last two foliage leaves of the previous season" and it has been protected over winter only by the decaying remains of these petiole bases. In our study these were the early flowering shoots which appeared outside of the dormant bud and before the scale leaves of this bud had opened. But we frequently found two inflorescences developed from within the bud, making a total of three inflorescences. Shull (1925) states that "an extreme of four has been reported."

Inflorescences that did not become fruit went in two ways. Mostly they became soft and degenerated rapidly, but a few withered and dried. These could be found for as much as a month after flowering. The spathe decayed soon after fertilization of the successful flowers and the compound fruit began to enlarge. Sometimes it became buried due to flooding by the stream after a heavy rain. Others were fully exposed, though on the marsh they were covered by the associated plants. The rate of growth and eventual size did not seem to correlate with forest or marsh, buried or exposed.

The matter of decay is interesting in this species and invites attention. The rapidity with which a large percentage of the inflorescences disappear, with no sign of mold prompts a query about autolysis and bacterial decay. No study of this was made. The leaf blades likewise disappear quickly and the petioles only somewhat more slowly through the summer, leaving no litter. The plant area is clear come September, except for fruit and buds. The fruits soften and more or less disintegrate with maturity of the seeds. A flower can produce only one seed but this is well imbedded in the enlarged compound fruit (spadix), and is liberated by decomposition of the latter. This decomposition may extend from late August into December. The seed, about a quarter inch in diameter, does not decay readily. Fruits brought to the laboratory in autumn

and left standing in water promptly began to decompose but the seeds remained firm through the winter. They did not germinate under these crude laboratory conditions.

Germinated and ungerminated seeds can be found along the brook, in the mud, or on logs, etc., in the vicinity. They have been found in late autumn, winter, and early spring but, though observed for weeks (they always disappeared eventually) the growth was so small that neither time nor stimulus of actual germination was determined.

Nature tends to be productive. The organisms produced ultimately become the food of other organisms, larger or smaller. Skunk cabbage appears to feed few herbivores

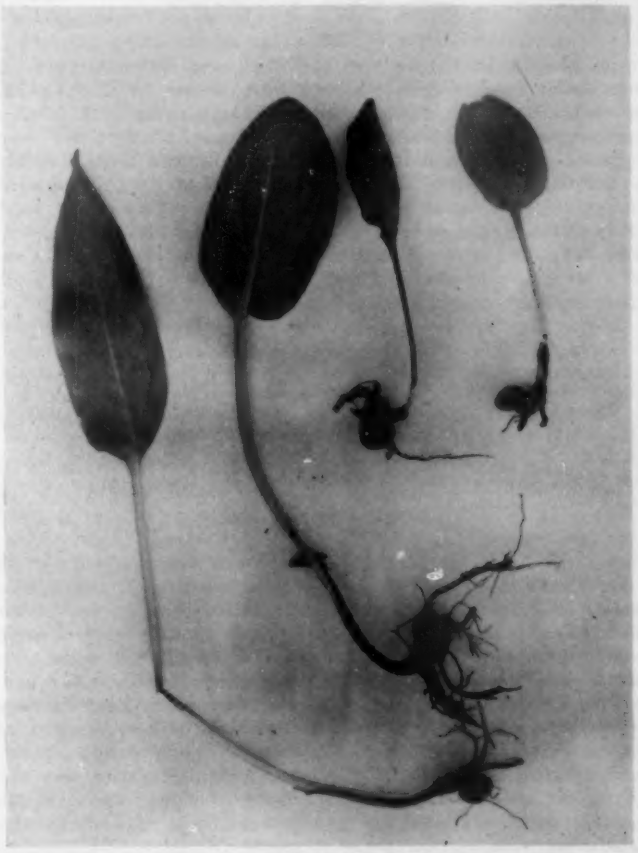

FIG. 2. Young plants lifted May 25, 1955, showing seed and beginning of rhizome formation.

unless it be the organisms of decay. The leaves have not been grazed upon. The fruits have not been found chewed or cut up as are those of May apple. Only rarely has there been evidence of "nibbling." In late winter whole buds have been found floating in the water. They appeared as though cut off, they were not chewed. They have been more numerous some seasons than others but no explanation has been conclusively apparent. Frost has been considered. Frost heaving of germinated seeds has been observed.

The seed is occasionally at least an item of diet. Whole seeds have been recovered from the crop of pheasant. Small piles of seeds have suggested the accumulating instinct of rodents. Further evidence of this has been the presence of seedlings at con-

siderable distances from the seed producing area, but neither chewed seeds nor rodents working on the seed producing area have been observed, though fruit has been found from which some seeds had been removed.

The seeds that have germinated after transportation from the producing area appear to develop plants which persist for more than one season. Such plants have been found with seed attached and also with a short erect rhizome but no sign of seed. One or two small leaves have been found on such plants (Fig. 2). No flowering or thrifty adult plants have been found more than a few meters from the stream or its seasonally flooded area. So the skunk cabbage remains confined to wet, muddy areas of woods or marshes.

This plant is common in many places over its range. Fernald (1950) describes the range as across lower Canada from western Nova Scotia to southeastern Manitoba, southward across Iowa, Illinois, Indiana, Ohio, West Virginia and in the uplands of Tennessee and Georgia. But what about the Costal Plain? Stone (1911) reports: [New Jersey] "Frequent . . . throughout the Northern, Middle, and Cape May districts." But also: "The Skunk Cabbage is not found in Pine Barrens" . . . . And again: [It] "is apparently absent from the coast strip, as diligent search has failed to detect it between Cape May Court House and Bay Head." Fernald (1950) includes Long Island, but what parts? What is the situation with Staten Island? What is the environmental tolerance of this plant?

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FIELD TRIP REPORTS

May 17. Dobb's Ferry, N. Y. The area visited was an old estate of eighty acres with many exotic trees and shrubs, 135 forms identified, and we had a time searching through the literature for some of the varieties. A beautifully shaped northern spruce, *Picea abies*, and a 65 foot cucumber magnolia, *Magnolia acuminata*, were found. *Conium maculatum* and *Hydrophyllum virginianum* were the most obvious herbaceous plants at the time. There were acres of pachysandra and myrtle. These plants, with Japanese honeysuckle and poison ivy, account for about 80% of the ground cover. We found a neglected "formal garden" with an arbor of espalierd apple trees, trained to arch over the path, with the tips grafted overhead. Bird migration was at a minimum but we did identify 56 species during the day. The trip ended with a visit to the Boyce Thompson Institute grounds to see the tree peonies display, courtesy of Miss Polly Storrs. A delightful day with a grand group of people. Attendance 34. Leader, E. Whelen.

May 24. Franklin Lakes, N. J. The most spectacular part of this trip is always the walk through the Clove, long may it remain. A stand of six or eight persimmon trees were of particular interest to the group. Ten fern species were noted, including all three Osmundas. Six species of *Viola* were recognized, and twenty-five other species of "spring flowers" of which the following are less frequently encountered. Purple virgin's bower, wild columbine, naked miterwort, wild ginger, bloodroot, blue cohosh, shin-leaf, rattlesnake weed, red baneberry, and white baneberry. Attendance 14. Leaders, Harry and Lucy Kemp.

May 31. Ward's Point, Staten Island, N. Y. Walking down to the shore through the old Butler Estate, the members noted a number of native and introduced trees:

Pinus strobus, P. rigida, P. nigra, Tsuga canadensis, Castanea sativa, Acer rubrum, Celtis occidentalis, Liquidamber, Robinia pseudo-acacia; and near the beach *Prunus maritima* and *Myrica carolinensis.* Along the beach there were few plants of note but shells and birds were pointed out. At Ward's Point, the most southern point in the state of New York, there were some of the seashore plants, such as *Xanthium echinatum, Cakile edentula, Iva frutescens, Salicornia europea* and *Limonium carolinianum.* Walking inland back toward the cars we found an abundance of *Rhus toxicodendron* in flower, *Equisetum arvense, Pteridium aquilinum, Quercus palustris* and at the corner of Hylan Blvd. the large *Quercus rudkini,* and the nearby *Quercus phellos.* Probably the outstanding find was a discovery of a morning glory, about which Mr. Joseph Monachino, Chairman of our Field Committee, reports as follows: "An interesting problem regarding *Convolvulus* (*Calystegia*) *sepium* evolved during the Ward's Point trip, but unfortunately not the solution. We saw along the coastal area great pure stands of the American variety with soft-pubescent foliage and roseate flowers. The striking character of close soft pubescence was uniform, suggesting a stolid variety. The leaf blades were broad; their basal lobes were sometimes angulate, often not. This bellbine of Ward's Point would key out to *C. repens* in Taylor's 'Flora of the Vicinity of New York.' However, it is not recognized as a proper species in the recent manuals. Also, it presents a problem when examined with respect to the two basic reference works. In Gleason's New Illustrated Flora, if the basal leaf-lobes are considered to be 'with 1–3 conspicuous but scarcely acute angles' then our plant keys out to var. *sepium,* which it is not, as the European specimens are different; if considered 'obtuse or rounded', to var. *Americanus* as to leaf-shape and flower-color. The leaf proportions and pubescence, on the other hand, unhappily relegate it to *C. sepium* forma *malachophyllus* Fernald in Fernald's 8th ed. Gray's Manual; var. *americanus* is synonymized with the typical form by Fernald, and that it is not. I have prepared a specimen for the local flora herbarium of the New York Botanical Garden." Attendance 20, Leader, Mathilde P. Weingartner.

June 14. Reed's Valley, Staten Island, N. Y. This walk led up a pleasant valley which separates into five distinct brook courses, leading thru serpentine outcroppings. On the serpentine were some plants of *Arabis lyrata,* and we relocated one plant of *Asplenium platyneuron.* In the woodland going up the hillside was a profusion of *Azalea nudiflora* and *Vaccinium corymbosum,* beneath a cover of *Quercus alba, Q. rubra, Q. velutina, Fagus grandifolia* and *Fraxinus americana.* There were some small trees of *Castanea dentata,* sprouts from old stumps. At a stagnant pond were located: *Peltandra virginica, Riccia fluitans* and lots of *Lemna minor.* The *Azolla* that had been introduced here was not in evidence. At a brookside, where forget-me-nots were expected, they were not found but a few plants of *Chrysosplenium ioense* were found. A large shrub of *Corylus americana* was found next to a cherry tree, the latter loaded with sweet cherries. In Grasmere, after we had left the valley, we explored another pond area, but no new discoveries were made. At the Nesslinger's, the garden was a pleasant wildflower experience. Here we saw many wildflowers and trees that Mr. Nesslinger had naturalized in the area. Many spruces had been planted, also *Albizzia, Rubus Phoenicolasius, Galax aphylla, Larix americana, Kalmia latifolia, K. angustifolia, Adiantum pedatum, Lorinseria* (*Woodwardia*) *areolata, Dryopteris phegopteris, Polystichum acrosticoides, Cicuta maculata,* and a Bamboo-like grass. Attendance 17, Leader, Mathilde P. Weingartner.

June 21. Spruce Pond, Southfields, New York. This was the first Torrey trip into this interesting area since June 1953. Reported in Bull. Torrey Club **80**: (No. 6) p. 515. 1953. Since that date the shrub thicket has advanced completely to the water's edge with the result that both cranberries have virtually disappeared. No ferns were added to the area's list but *Carex trisperma* was found, this report extending its range southward in New York State. Attendance 11. Leader, J. Harry Lehr.

June 28. Jamaica Bay Wildlife Refuge, N. Y. We assembled at the parking field on Cross Bay Boulevard and found a really cosmopolitan group—some of whom were for the birds. Since this is a sanctuary and the place is always alive with shorebirds, terns

and skimmers, we elected to visit the heronry and the tern colony first. We had fine views of these interesting birds and found the nests of terns and green herons. In covering the area we noted the continuing changes in the ecology, from saltmarsh to fresh water ponds, the result of diking and impounding works. Outside the dike is saltmarsh, with marsh pink (Sabatia stellaris), marsh fleabane (Pulchea camphorata), and glasswort (*Salicornia* sp.) as common plants, while inside the dike we now have ladies tresses (*Spiranthes cernua*), willow herb (*Epilobium* sp.) and hardhack (*Spirea tomentosa*) taking hold. There's an easy air of friendliness on Torrey Club trips that this leader enjoys. Everyone had a nice day and a few of us learned a thing or two—with Jim Murphy along, who wouldn't!? Attendance 30. Leader, E. J. Whelen.

July 5. Clove Lakes Park, Staten Island, N. Y. The three lakes had been used for ice harvest during the early part of the century. The city took the area for a park, the dams were raised, and a once good swamp has now become a lake. The park supports many native as well as introduced species of plants. Among the intentionally introduced plants were mostly trees and shrubs, such as *Cercis canadensis, Pinus strobus, Tsuga canadensis,* and many species of *Crataegus.* There were sizable stands of the introduced Japanese plumegrass.

Along the shore of the ponds were lovely stands of *Pontederia cordata, Sagittaria latifolia,* and *Cicuta maculata.* The common ferns were: *Dennstaedtia punctilobula, Pteridium aquilinum, Dryopteris noveboracensis, Athyrium Filixfemina,* and one plant of *Asplenium platyneuron* found on an outcropping of serpentine.

Someone pointed out a nearby "Indian cave" in the serpentine which used to harbor little boys that ran away from home (school?) until the Department of Parks filled up the cave.

A remarkable plant of the park is a large *X-Quercus heterophylla* (Bartram oak) which was planted as an acorn by William T. Davis in 1888, making it 71 years old. The tree is very healthy looking. Many will remember William T. Davis (See Torrey Field Schedule 1946) and his extraordinary trips for hybrid oaks on the Island. Bartram oak is considered to be of frequent occurence in parts of the New Jersey costal plain. Fernald notes it unequivocally as *Q. phellos x Q. rubra* but Witmer Stone (Plants of Southern N. J. in Ann. Rept. N. J. State Museum, 1910 (1911) stated, "that is certainly not the case in New Jersey." He pointed out that in the area where *Q. phellos* is common, *Q. rubra* is rare, *Q. coccinea* and *Q. velutina* are more plentiful. Attendance 15. Leader, Mathilde P. Weingartner.

July 11. Staten Island, N. Y. Those attending went by local bus to the Hugenot Park-Wolf Pond area which affords a variety of upland fields and woods as well as fresh water ponds, bogs, and seaside flora. A large stand of purple milkwort, which is rather rare on Staten Island, was found in the area but the trip was primarily for grasses. The following species were found and may be worth putting in the permanent record: *Agropyron repens* (L.) Beauv., *Agrostis alba* L., *A. hyemalis* (Walt.) BSP., *Ammophila breviligulata* Fern., *Andropogon virginicus* L., *Anthoxanthum odoratum* L., *Arrhenaterum elatius* L., *Cenchrus tribuloides* L., *Cinna arundinacea* L., *Dactylis glomerata* L., *Danthonia spicata* (L) Beauv., *Deschampsia flexuosa* (L.) Trin., *Elymus virginicus* L., *Eragrostis pilosa* (L.) Beauv., *Festuca elatior* L., *Holcus lanatus* L., *Leersia virginica* Willd., *Lolium perenne* L., *Miscanthus sinensis* Anders., *Panicum amarum* Ell., *P. clandestinum* L., *P. hauchucae* Ashe., *P. microcarpon* Muhl., *P. virgatum* L., *Phleum pratense* L., *Phragmites communis* Trin., *Poa annua* L., *P. compressa* L., *P. pratensis* L., *Spartina patens* (Ait.) Muhl., *Tripsacum dactyloides* L. Attendance 8. Leader, Robert C. Meyer, Jr.

BOOK REVIEWS

Comparative Morphology of Vascular Plants by Adriance S. Foster and Ernest M. Gifford, Jr. Freeman and Co. San Francisco. 1959. $9.00.

This textbook is refreshingly straightforward in style and fulfills the authors' aim

to "display clearly the procedures, general principles, and objectives of comparative morphology." The need for highly trained morphologists and for botanists with a thorough grounding in morphology is increasing; Foster and Gifford have produced a text admirably suited for training both. They are to be commended for the critical selection of material, for balance, for developing the student's awareness of morphological problems requiring attention, and for a skillful introduction to the pertinent literature of morphology. Comparative morphology emerges from this treatment as a dynamic botanical discipline with almost unlimited possibilities for research in both temperate and tropical floras.

One quarter of the book, the first six chapters, is devoted to the procedures, principles and objectives of comparative morphology under the general headings of: the science of plant morphology, the salient features of vascular plants, the vegetative, sporophyte, sporangia, gametangia, and embryogeny. The concept of homology, often almost entirely neglected in botanical textbooks, is discussed with appropriate examples; unfortunately a critical definition of the term homology is not given. Serial homology, based upon method of origin and position, is shown to be a useful concept, particularly in the development of the shoot and its appendages.

The treatment of the sporophyte and gametophyte generations, and alternation of generations is clearly conceived; reference is not made to sexual or asexual generations. However, considering the confusion generally created in discussing these topics in most general botany and general biology textbooks, it might have been wise to have made reference to Wahl's stimulating paper on alternation of generations.[1]

The foundations for comparative study are further laid in the chapter on the vegetative sporophyte through consideration of types of branching in shoots, microphylls vs. megaphylls, the telome theory, and a particularly lucid exposition on the anatomy of the sporophyte which is climaxed by a discussion of the stelar theory. These early chapters focus the student's attention upon adult form and structure, the fossil record, ontogeny, physiology, and morphogenesis as the chief sources of evidence in comparative morphology.

Three fourths of the book, thirteen chapters, is required to present the comparative morphology of vascular plants from the Psilopsida through the reproductive cycle in angiosperms. A detailed account chapter by chapter will not be attempted; the following, however, merit particular attention: (1) The care with which illustrative material has been selected from the tremendous amount of morphological material available today; ample coverage is included for the terminal undergraduate course and at the same time an adequate foundation is built for extensive study into the literature at the graduate level. (2) The recommendation that the development of sporangia, leaves, shoot apex etc. not be considered in isolation but rather in terms of broad patterns of morphological development which may be reflected in the organography of a species or members of a natural group. (3) That evidence for possible phylogenetical evaluation be drawn from all parts of the plant, with emphasis on the importance of ontogenetic study, and (4) The excellent summaries on chromosome numbers and their significance in the lower vascular plants.

In the opinion of this reviewer, a textbook in comparative morphology can be judged for both adequacy of coverage and soundness of interpretation by checking on certain key topics: the sporangiophore of *Equisetum*, the evolution of the seed habit, the morphological nature of the megasporangiate strobilus in the Coniferales, wood anatomy in the angiosperms, and the interpretation of the flower. Foster and Gifford score very well on these; they have maximized emphasis on structure and minimized theoretical implications which wisely are left for the consideration of the instructor. The term sporangiophore is reserved for use in the Sphenopsida, no attempt is made to homologize it with the sporophyll of the Lycopsida or of that in the higher vascular plants.

The structure of the seed in both fossil and living forms is discussed in detail with reference to ontogenetic development. The student is cautioned that the terms microspore

[1] Wahl, H. A. 1945. Alternation of generations and classification with special reference to the teaching of general botany. Torreya **45**: 1–12.

and megaspore as applied to seed plants do not necessarily convey an idea of relationship to the lower heterosporous vascular plants, and also that the evolutionary history of the seed can not be reconstructed from the fossil record because of existing gaps.

The megasporangiate strobilus in the Coniferales is interpreted as being "compound" in nature in accord with the brilliant discoveries of Florin in *Lebachia Ernestiodendron*, *Pseudovoltzia*, and *Voltzia*. Thus, the ovuliferous scale or seed scale complex represents an axillary fertile shoot which, throughout extensive evolution, has undergone conspicuous reduction and fusion.

Clarity and comprehension have been gained in the treatment of angiospermous wood in limiting it to the evolution of the vessel and to the occurrance of vesselless species in the Ranales and the possibility that both the dicotyledons and monocotyledons arose from woody, vesselless ancestral types.

Strong support is given the so-called classical interpretation of the flower from the relatively recent works of Eames, I. W. Bailey, Canright, McVoy, Swamy, and Tepfer.

The text is enhanced by 213 detailed line drawings, photographs, photomicrographs, and diagrams. Each figure is clearly labelled, beautifully reproduced, and cogently illustrates and amplifies the text material. A minor blemish is seen in Figure 13–16, B, in which the rhizome of *Pteridium* is inverted.

In "Comparative Morphology of Vascular Plants" Foster and Gifford have written a most rewarding textbook and one which will undoubtedly become a standard work for English-speaking countries.—MARION A. JOHNSON, Department of Botany, Rutgers, The State University of New Jersey.

Fundamentals of Plant Physiology. By James F. Ferry and Henry S. Ward. viii + 288 pages, Fig. 1–130. The Macmillan Company, New York. 1959. $6.50.

The authors present the more important aspects of plant physiology for students in a one-semester course; and realizing the limitations of such students they have included brief reviews of pertinent facts from elementary chemistry, physics and general botany. They have done well to present as much of this material as they have in so short a text. Also they have made use of tables and illustrations from many sources. Their discussions of the more descriptive subjects are quite adequate for a short course, and it is gratifying to find so many of the newer lines of research mentioned.

However, one frequently has the impression, while reading the book, that the manuscript should have been revised more carefully, before sending it to the printer. Some of the graphs taken from sources in the literature probably will not mean much to the student because of insufficient explanation. Statements are made that certain facts are shown by these graphs, but the meaning of some of the symbols used are not explained for figures 13, 17, and 18; the three lines of figure 14 are not differentiated, and figure 98 does not seem to illustrate the experiment described. In some places it seems the order of presentation could be improved. Sometimes a topic is introduced and briefly described, then there is some diversion to talk about something else, and a few pages later the original topic is taken up again in more detail. On p. 46 the temperature coefficient of water absorption is mentioned and the term "Q_{10}" is used as though the students were supposed to be familiar with this concept and its abbreviation. Then on p. 153 the term and its symbol are carefully explained in connection with the effect of temperature on the rate of respiration, and on p. 249 it is explained again in broader terms as van't Hoff's law. On p. 134–5 enzymes are briefly described in a paragraph and some of the factors affecting the rate of their activities are stated. On p. 144–5 enzymes are again described with only a few additional details. Near the end of the book there is a section of seven pages entitled "Growth Correlations," but after a short introductory paragraph, the authors digress for nearly two pages to discuss translocation in the phloem. This is the only specific discussion of this subject in the book.

In the chapter on water relations most of the terms are correctly defined, but the discussion of diffusion pressure seems confused. Also in several places permanent wilting

is referred to as though it were a definite stage in the drying out of plant cells or tissues rather than the condition of a plant in a soil of a certain low water content.

Several other instances might be cited where the concepts of the authors seem at variance with common usage, but I shall mention only two. Although the protein nature of enzymes is mentioned on p. 145, on p. 149 the adenine derivatives, ADP and ATP, are referred to as "phosphate enzymes." The authors rather go out of their way to point out the vagueness of the term "assimilation" and then somewhat arbitrarily decide to consider as products of assimilation lignin, cutin, latex, and other "organic end products found in cells which are not generally recognized as foods." This seems justified because the synthesis of such things involves the absorption of organic and inorganic substances by the protoplasm and the transformation of these substances apparently within the protoplasm. In a broad sense, the synthesis of cell inclusions could be considered similar to the formation of the cell wall. Still, I feel that "assimilation" should not be synonymous with "synthesis," and to use the word as a verb, as one might use "synthesize," only adds to the confusion. One reads with some surprise the statement on p. 179: "The importance of the rapidly increasing use of antibiotics assimilated by fungi is well known."

On the whole the authors have presented a great deal of material for their students in a small space. They have rightly emphasized the complicated interaction of genetic traits, biochemical reactions, and the many factors of environment which are involved in the growth of plants; thus giving their students some further details and a better insight into the behavior of plants than they probably retain from general botany. But I feel it could have been done much better.—HAROLD H. CLUM.

Spring Flowers of the Lower Columbia Valley. By Clara Chapman Hill. Illustrated by Mary Comber Miles. xii + 164 pp. Many full-page line drawings. University of Washington Press. 1958. $3.00.

A handbook designed primarily for the beginner in plant identification, interested in the conspicuous flowering plants of spring in the vicinity of Portland and adjacent counties. The simple keys to genera and, in the case of larger genera, to species, together with interesting notes concerning each species described, and with Mrs. Miles' graceful and accurate drawings, make of the book a usable guide to spring flowers of the region.—HELEN M. GILKEY.

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INDEX TO AMERICAN BOTANICAL LITERATURE

COMPILED BY

LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITOR OF BRITTONIA

TAXONOMY, PHYLOGENY AND FLORISTICS

ALGAE

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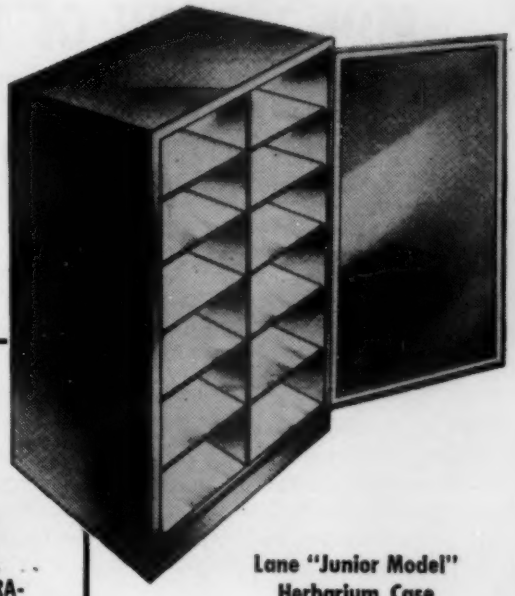

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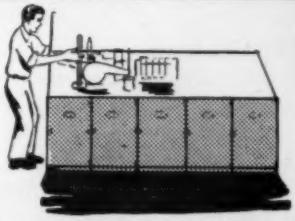

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MONOGRAPH OF THE GENUS ARGEMONE FOR NORTH AMERICA AND THE WEST INDIES

by

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